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ISSUED QUARTERLY
CHAPEL HILL, N. C., U. S. A.
ENTERED AT THE POST OFFICE AS SECOND-CLASS MATTER

The Elisha Mitchell Scientific Society

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COLLIER COBB

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by the
University of North Carolina

PLATE 1

FIG. 1. COLLYBIA LILACINA n. sp. No. 3290
FIG. 2. COLLYBIA CIRRATA. No. 3743
FIG. 3. COLLYBIA PLATYPHYLLA. No. 1263

JOURNAL

OF THE

Elisha Mitchell Scientific Society

Volume XXXVII DECEMBER Nos. 1 and 2

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, FEBRUARY, 1921, TO MAY, 1921

246th Meeting—February 8, 1921

Dr. Edward J. Wood (Class of 1899), of Wilmington, N. C.—*Our Debt in Medicine to the British.*

The speaker mentioned briefly a few of the outstanding contributions to the making of modern medicine by the British. The pioneer worker was William Harvey who described the circulation of the blood and must be accredited with the discovery. Special reference was made to that little group of nineteenth century physicians in London who, at Guy's Hospital, made such a remarkable contribution within a few years. There was Addison who first described Addison's disease, Bright who first described Bright's disease, Hodgkin who first described Hodgkin's disease and finally Sir Ashley Cooper, a great surgeon and a pioneer in medical education.

The real burden of the address was the contribution in parasitology. The remarkable achievements of Sir Patrick Manson were mentioned briefly, the genius of Louis W. Sambon applying his great knowledge of medical zoology, the discovery of the mosquito in its role in malaria transmission by Sir Ronald Ross, the work of Sir David Bruse and others in determining the relation of the trypanosome to sleeping sickness of Africa and the relation of the tse-tse fly to its transmission. The work of Sir William Leishman in the discovery (with division of honor to Donovan) of the protozoal cause of dum-dum fever of India.

The need of a medical zoological survey in North Carolina was mentioned. It was hinted that schistosomiasis had been recently found in the state and at least one case of kala-azar. The educational need along these lines was also emphasized.

247th MEETING—MARCH 8, 1921

W. C. GEORGE.—*Comparative Anatomy of the Brain.*

The principal morphological subdivisions and connections of the human brain were described and their probable phylogeny outlined. The relation of the environmental conditions and habits of life of animals to the degree of development of special parts of the brain was indicated. Dissections of brains of an elasmobranch fish, a frog, reptile, bird, rat, mole, cat and man were exhibited to show homologous parts of the brain and the degree of development under different conditions of life.

OTTO STUHLMAN, JR.—*Some Unsolved Problems of Modern Physics.*

No science has gone through a more stormy period of development than physics during the last decade. Our most cherished theories have undergone most violent upheavals, the result of which no one at this time can predict with certainty. These discoveries have forced us to adopt new and contradictory explanations, which in general may be divided into three groups: (*a*) **X**-rays and the emissions from radio-active substances; (*b*) The theory of radiation; (*c*) The so-called theory of relativity.

Of these the "Theory of Radiation" was discussed and some of the outstanding problems that require solution were explained in detail.

Amongst those mentioned was Wien's Displacement Law and the contributions made by Planck. The classical theory of specific heat and entropy and its quantum modifications were discussed. The quantum theory as applied to the emission of electrons from bodies was mentioned and some of the outstanding problems were discussed in detail. The unsolved problems in the photo-electic field were next enumerated and their possible bearing on the structure of matter was sketched. Series spectra and the numerous problems confronting the physicist in this field were finally enumerated. The paper closed with a review of the Lewis-Langmuier theory of the structure and physical properties of nitrogen and carbon monoxide.

248th MEETING—APRIL 12, 1921

THORNDIKE SAVILLE—*The Water Power Situation in North Carolina.*

This paper presents the results of a statistical study of the devel-

oped hydro-electric power in North Carolina. It is shown that there is at present a total installed capacity of about 356,000 H. P. in plants producing hydro-electric power. Of this, 80,000 H. P. or 22 per cent is transmitted for use outside the state; 113,000 H. P. or 32 per cent is used at Badin in the local reduction of aluminum; while only 164,000 H. P. or 46 per cent is available for general industrial and public use. Of the latter 98,500 H. P. or 28 per cent of the total (60 per cent of the 164,000 generally available) is developed by two large public service corporations.

The total output of electrical energy by public service plants has increased 25 per cent from 1919 to 1920, and over 6000 per cent from 1907 to 1920. If the output increases at 12 per cent per year (one half the present annual rate) there will be a demand in 1925 for 1,434,000 kw. hr. and in 1930 for 2,528,000 kw. hr. To meet this demand, if the present proportion of output by water power is to be maintained (85 per cent) there will be needed additional development of 200,000 H. P. by water power in 1925 and of 624,000 H. P. by 1930. To develop this amount of water power will mean many new hydro-electric installations in the state, and the utilization of most of the economically available water power sites. It is estimated that about 1,500,000 H. P. is still undeveloped at sites in this state, but only a portion of this amount can be economically developed under present conditions.

FRED F. BAHNSON (Class of 1896), of Winston Salem, N. C.—*The Science of Humidification, with Demonstration of a New Humidifier.*

Entirely too little attention has been paid to humidification in all manufacturing processes except those where the advantages are very plainly apparent, such as textiles. All materials of animal or vegetable origin and a number of mineral origin are affected by the humidity of the air in which they are stored or used, and this effect is proportional to the relative humidity or percentage of saturation, rather than the actual humidity or pounds of water per thousand cubic feet of space.

Since the weight of a cubic foot of saturated aqueous vapor just about doubles for each twenty degrees rise in temperature, it is obvious that even if the out-door humidity is sufficiently high, the indoor humidity will always be too low whenever artificial heat is used. This simply means that artificial means of supplying moisture must be used practically every day in the year, because even in summer

weather out-door humidity is apt to be below what it should be for satisfactory manufacture.

With exception of textile fibres, the curves for moisture content of various materials with reference to atmospheric conditions have not been determined.

The various commercial methods of humidification were mentioned and briefly described, and the Bahnson Humidifier was demonstrated under actual operating conditions.

249th MEETING—MAY 10, 1921

ARCHIBALD HENDERSON—*The Lorentz Transformation in Einstein Relativity.*

Dr. Henderson attempted to give in the simplest possible mathematical terms the explanation of the Principle of Relativity (in the restricted sense), following the lines worked out by Einstein himself. After deriving the equations of the Lorentz transformations, Dr. Henderson gave their mathematical interpretation (1) The systems are entirely symmetrical; (2) A beam of light must have the same velocity, when viewed in the variables of either system; (3) The equations for low velocities reduce to the Newtonian equations; (4) A meter-stick perpendicular to the direction of motion remains constant. Analyzing these equations further, Dr. Henderson showed the interdependence of time and space which they present, so that the phrase "points" in "space" is replaced by the expression "events" in "the world." The invariance function was interpreted as indicating a "rotation" in four-dimension Euclidian space with imaginary time-axis; or else, a "rotation" in four-dimension non-Euclidian space with real time-axis. It was pointed out that the Einstein theory of Relativity raises the deepest questions regarding space, time, gravitation, and the essential characteristics of the physical universe.

W. C. COKER—*Effect of Length of Day on Growth and Reproduction of Plants.*

A review was given, illustrated by lantern slides, of the highly significant work of Garner and Allard on this subject. Mr. Allard was assistant in botany in this University sixteen years ago and went from here to the Department of Agriculture in Washington, where he is still working. In an extended series of experiments with growing plants the authors have shown that the length of day, that is the time

of exposure to light, is by far the most important factor in initiating or retarding the production of flowers and fruit. For example, a certain variety of soy-beans when exposed to light for only seven hours a day blossomed on June 15th, while those exposed to full daylight did not bloom until September 4th. The majority of the plants experimented with showed similar hastening of flowering when exposed to short day, but several plants responded in the opposite manner and were much retarded in blooming by a short day. The authors believe that their work will have a considerable practical effect on agriculture, as it shows that the time of seeding for best results will depend on the lengths of day to which the crops will be exposed. They also believe that the natural distribution of plants on the earth is governed more or less directly by the seasonal length of day which obtains for the different latitudes from the equator to the poles.

Election of Officers:

President—W. DeB. MacNider.
Vice-President—W. F. Prouty.
Permanent Secretary—J. M. Bell.
Recording Secretary and Treasurer—H. R. Totten.
Editorial Committee—W. C. Coker, chairman; J. M. Bell, Collier Cobb.

PROCEEDINGS OF THE TWENTIETH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

HELD AT WAKE FOREST COLLEGE, WAKE FOREST, N. C.
APRIL 29-30, 1921

The Executive Committee met at 2.00 P. M. on April 29th in the Lecture Room of the Alumni Building with the following present: Z. P. Metcalf, President, and C. S. Brimley, Acting Secretary, other members, R. N. Wilson, F. A. Wolf, and A. H. Patterson, the latter acting for H. R. Totten, who was absent.

President Metcalf stated that the Legislative Committee authorized at the last meeting of the Academy to solicit funds from the legislature had not been appointed, owing to the financial stringency existing in the state at the time of the session of that body. He also stated that affiliation with the American Association had been completed except for the official notice from the permanent secretary of that organization.

The Executive Committee then passed resolutions recommending the following measures to the Academy for favorable action:

1. Increasing the annual dues to $2.00 per member.

2. That the terms of the officers of the Academy should begin with the adjournment of the meeting at which they are elected, and should expire with the adjournment of the next regular annual meeting.

3. That the 10 per cent allowed the Secretary-Treasurer should be only on the Academy dues collected by him, and not on the American Association dues collected by him for that body in future.

4. Appointment of a Publicity Committee.

5. Appointment of a Committee on Preservation of our Natural Resources.

The Executive Committee then received and accepted the offer of the University of North Carolina to hold the 1922 meeting at Chapel Hill.

President Metcalf then announced that he had appointed Messrs. W. H. Pegram, R. N. Wilson, and A. H. Patterson to draw up suitable resolutions on the death of past-President of the Academy J. J. Wolfe, and that the same had been prepared and published in the Mitchell Journal, and that he had also appointed Messrs. W. L. Poteat and C. E. Brewer to do the same with regard to the death of past-President J. S. Lanneau.

Thirty-six new members were elected as follows:* W. J. Andrews, Miss Lucretia Baker, Miss E. E. Barrow, H. L. Blomquist, J. T. Barnes, Wayne Burch, Miss E. G. Campbell, L. A. Denson, R. T. Farrington, W. C. George, J. P. Givler, H. N. Gould, E. P. Jones, J. W. Lasley, Jr., W. Bruce Mabee, T. B. Mitchell, W. deB. MacNider, N. M. Paull, Charles Phillips, T. E. Powell, Jr., R. H. Ruffner, E. E. Randolph, A. F. Roller, Miss Mildred Sherrill, S. C. Smith, William E. Speas, Otto Stuhlman, Jr., R. W. Sullivan, C. C. Taylor, O. J. Thies, Jr., H. M. Vann, R. B. Wilson, Mrs. B. W. Wells, Miss Lula G. Winston, Miss E. K. Wright, D. B. Wilson.

The Executive Committee then adjourned.

The Academy met at 2:30 P. M., when papers were read and discussed. The following committees were then announced by President Metcalf: Nominating—W. L. Poteat, A. S. Wheeler, and C. W. Edwards. Resolutions—Messrs. Bert Cunningham, J. B. Derieux and A. H. Patterson. Auditing—Messrs. R. N. Wilson, J. W. Nowell and W. C. Coker.

The Academy then rose to accept the invitation of the Ladies' Community Club to take tea with them at the Golf Cabin.

At 8.00 P. M. the Academy re-assembled in Wingate Memorial Hall to hear the Presidential Address of President Z. P. Metcalf on the "Age of Insects," which subject he handled in a highly instructive and scientific manner. A very interesting paper on Judgments of Length, Mass, and Time by Dr. A. H. Patterson, of the University of North Carolina, followed, after which the Academy adjourned for the night.

On Saturday morning, April 30th, the Academy held its business meeting at 9.00 A. M., President Metcalf in the chair.

The Secretary then read the report and recommendations of the Executive Committee, all of which were adopted by the Academy.

The Nominating Committee then reported the following names for officers of the Academy for the year beginning May 1, 1921.

President—James L. Lake, Professor of Physics, Wake Forest College.

Vice-President—Joseph Hyde Pratt, State Geologist.

Secretary-Treasurer—Bert Cunningham, Professor of Biology, Trinity College.

Additional Members of the Executive Committee—Messrs. H. R.

* For addresses see full list of Academy membership.

Totten, University of North Carolina; R. N. Wilson, Trinity College; F. A. Wolf, State College.

The Secretary then on motion cast the vote of the Academy for these gentlemen and they were declared elected.

The Resolutions Committee reported the following resolutions which were adopted by a rising vote of the Academy:

1. That the North Carolina Academy of Science extend to the Faculty and President of Wake Forest College most hearty thanks for and appreciation of their courtesy in tendering the use of the buildings and equipment of the college for the meeting of the Academy, and in opening their homes to its members. This is the fourth meeting to be held here and our memory of Wake Forest, both of the town and of the college, has been one of consistent and generous hospitality.

2. That the North Carolina Academy of Science extend its thanks to the Ladies' Community Club of Wake Forest for the pleasant social courtesies extended to the members of the Academy at the Golf Club on yesterday afternoon and its hearty appreciation of the spirit of kindly hospitality which prompted the giving of the tea at the Club House.

The Auditing Committee then reported that they had examined the accounts of Secretary R. W. Leiby and Acting Secretary C. S. Brimley and found them correct and in good condition.

Reports follow:

REPORT of R. W. LEIBY, SECRETARY

Balance on hand April 29th, 1920 (audited)		$196.32
Receipts April 29 to Sept. 1, 1920		43.00
Interest April 29, 1920, to April 1, 1921		5.77
Total		$245.09
DISBURSEMENTS		
Expenses Secretary at 1920 meeting	.28	
Telegram to E. W. Gudger	.95	
Stenographic Services (Miss Hinsdale)	5.00	
Collection on check	.10	
Elisha Mitchell Journal	75.00	
		81.33
Balance on hand April 15, 1921		$163.76

REPORT of C. S. BRIMLEY, ACTING SECRETARY, MARCH 25 to APRIL 29, 1921

Receipts, dues and entrance fees		$105.00
Disbursements—		
Printing programs	$17.00	
Letterheads	6.00	
500 stamped envelopes	12.31	
Multigraphing 4 letters	3.00	
10 per cent. on $105.00	10.50	
		48.81
Balance on hand April 29		$56.19
Estimated Financial Condition of Academy—		
Leiby's balance	$163.76	
Brimley's balance	56.19	
Unpaid dues and fees (est.)	50.00	
For programs from Chemists	5.00	
Total Credit		$274.95
Expenses—		
Secretary's expenses at meeting	5.00	
10 per cent. on $50.00	5.00	
Elisha Mitchell Journal	75.00	
		85.00
Estimated balance Jan. 1, 1922		$189.95

President Metcalf then announced the appointment of the following committees:

Publicity—Bert Cunningham, Chairman; A. H. Patterson, W. A. Withers.

Preservation of Natural Resources.—Z. P. Metcalf, Chairman; J. S. Holmes, W. C. Coker, J. P. Givler, H. L. Blomquist, B. W. Wells.

On motion the Academy resolved to request the Mitchell Journal to publish the names of the officers and standing committees on the back of the Journal.

The Committee on Science Teaching in the High Schools was after some discussion continued and the business session ended.

The Academy then met in joint meeting with the North Carolina Section of the American Chemical Society and heard several papers, after which the chemists and physicists held a joint session separate from the remainder of the Academy.

After the reading of the last paper the Secretary reported that he had received a letter from Dr. E. W. Gudger, stating how much he had

appreciated the Academy meetings in the past and how much he missed them now that it was impossible for him to attend. He furthermore stated that he would retain his membership, and extend his best wishes for a successful meeting. On motion the Secretary was instructed to write Dr. Gudger, thanking him for his continued interest and good will.

The Academy adjourned at 3 P. M. to meet at Chapel Hill in 1922.

Following is the present membership of the Academy. Those marked with an asterisk were present at the meeting.

Andrews, William J., Civil Engineer.....Raleigh, N. C.
Arbuckle, H. B., Professor of Chemistry, Davidson College.....Davidson, N. C.
Babb, Josiah S., Dept. of Geology, University of North Carolina.....Chapel Hill
Bahnson, F. F., 28 Salisbury Road.....Winston-Salem, N. C.
Baker, Miss Lucretia, Meredith College.....Raleigh, N. C.
*Balderston, Mark.....Guilford College, N. C.
*Barnes, J. T., Dept. of Biology, Trinity College.....Durham, N. C.
Barret, Dr. H. P., 211 Vail Ave.....Charlotte, N. C.
Barrow, Miss Elva E., North Carolina College for Women.....Greensboro, N. C.
*Bell, J. M., Smith Professor of Chemistry, University of North Car....Chapel Hill
Binford, Raymond, President Guilford College.....Guilford College, N. C.
Bonney, Miss E. C., 1421 Fourteenth Ave.....Hickory, N. C.
Bottum, Miss F. R., St. Mary's School.....Raleigh, N. C.
*Blomquist, H. L., Dept. of Biology, Trinity College.....Durham, N. C.
Brewer, C. E., President Meredith College.....Raleigh, N. C.
*Brimley, C. S., Division of Entomology, N. C., Dept. of Agriculture, Raleigh, N. C.
Brimley, H. H., Curator State Museum.....Raleigh, N. C.
Browne, Wm. Hande, Dept. of Electrical Engineering, State College, Raleigh, N. C.
Bruner, S. C., Estacion Agronomica.....Santiago de las Vegas, Cuba
*Bullitt, J. B., Professor of Pathology, Univ. of North Carolina.....Chapel Hill
*Burch, Wayne, Trinity College.....Durham, N. C.
Cain, William, Kenan Prof. Emeritus of Math., Univ. of N. C.....Chapel Hill
*Campbell, Miss Eva G., Dept. of Biology, North Car. Coll. for Women, Greensboro
Clapp, S. C., Superintendent State Test Farm.....Swannanoa, N. C.
Cobb, Collier, Professor of Geology, University of North Carolina....Chapel Hill
Cobb, William B., Louisiana State University.....Baton Rouge, La.
*Coker, W. C., Kenan Prof. of Botany, Univ. of North Carolina.....Chapel Hill
Collett, R. W. .....White Hall, S. C.
Couch, J. N., Biology Teacher, Charlotte High School,.....Charlotte, N. C.
*Cunningham, Bert, Professor of Biology, Trinity College .....Durham, N. C.
Davis, Harry T., Assistant Curator State Museum.....Raleigh, N. C.
Denson, Lee A., U. S. Weather Bureau.....Raleigh, N. C.
*Derieux, J. B., State College.....Raleigh, N. C.
*Dixon, A. A., State College.....Raleigh, N. C.
Downing, J. S.....Elsmere, Del.

*Edwards, C. W., Professor of Physics, Trinity College.....Durham, N. C.
Farmer, C. M., 115 Orange St.....Troy, Ala.
*Farrington, R. K., Trinity College.....Durham, N. C.
George, W. C., Assoc. Prof. of Histology and Embryology, Univ. of N. C., Chapel Hill
*Givler, J. P., Professor of Biology, North Carolina College for Women, Greensboro
*Gould, H. N., Dept. Biology, Wake Forest College.....Wake Forest, N. C.
*Gross, Paul, Dept. of Chemistry, Trinity College, 1001 Trinity Ave..Durham, N. C.
Groves, Miss Pattie J., 802 Watts St.....Durham, N. C.
Gudger, E. W., American Museum of Natural History.....New York City
*Haber, V. R., Division of Entomology, N. C. Dept. of Agriculture..Raleigh, N. C.
*Halverson, J. O., N. C. Dept. of Agriculture.....Raleigh, N. C.
Hatley, C. C.....Durham, N. C.
Heck, C. M., State College.....Raleigh, N. C.
Henderson, Archibald, Prof. of Mathematics, Univ. of North Car....Chapel Hill
Hickerson, T. F., Prof. of Civil Engineering, Univ. of North Car.....Chapel Hill
Hobbs, A. W., Associate Prof. of Mathematics, Univ. of North Car...Chapel Hill
Hoffman, Dr. S. W.....Statesville, N. C.
Holland, Miss Alma, Dept. of Botany, Univ. of North Carolina.....Chapel Hill
Holmes, J. S., State Forester.....Chapel Hill
Ives, J. D., Stetson University, Deland, Fla.....Pine Bluff, N. C.
Ivey, J. E., State College.....Raleigh, N. C.
*Jones, E. P., Trinity College.....Durham, N. C.
Kilgore, B. W., Director of Experiment Station.....Raleigh, N. C.
Krausz, H. B.....Raleigh, N. C.
*Lake, J. L., Prof. of Physics, Wake Forest College.....Wake Forest, N. C.
Lasley, J. W., Jr., Assoc. Prof. of Mathematics, Univ. of North Car...Chapel Hill
*Lehman, S. G., State College.....Raleigh, N. C.
Leiby, R. W., Division of Entomology, N. C. Dept. of Agriculture..Raleigh, N. C.
Lewis, Dr. R. H.....Raleigh, N. C.
Lugn, A. L., Dept. of Chemistry and Physics, Lenoir College.....Hickory, N. C.
Mabee, W. Bruce, Div. of Entomology, N. C. Dept. Agriculture...Raleigh, N. C.
MacNider, W. DeB., Kenan Prof. of Pharmacology, Univ. of N. Car., Chapel Hill
Marion, S. J., Dept. of Chemistry, State College.....Raleigh, N. C.
Markham, Blackwell, 92 Toxtech St.....Brookline, Mass.
Mendenhall, Miss Gertrude, 1023 Spring Garden St.....Greensboro, N. C.
*Metcalf, Z. P., Prof. of Zoology and Entomology, State College..Raleigh, N. C.
*Mitchell, T. B., Div. of Entomology, N. C. Dept. Agriculture....Raleigh, N. C.
*Nowell, J. W., Wake Forest College.....Wake Forest, N. C.
*Patterson, A. H., Professor of Physics, Univ. of North Carolina.....Chapel Hill
Paull, N. M., Assistant Professor of Drawing, Univ. of North Car...Chapel Hill
Pegram, W. H., 308 Buchanan Road.....Durham, N. C.
Petty, Miss Mary, North Carolina College for Women.....Greensboro, N. C.
*Phillips, Charles, Dept. of Pathology, Wake Forest College....Wake Forest, N. C.
Pillsbury, J. P., State College.....Raleigh, N. C.
Plummer, J. K., 499 Courtland St.....Atlanta, Ga.
*Poteat, W. L., President Wake Forest College.....Wake Forest, N. C.
Powell, T. E., Jr., Professor of Biology, Elon College.....Elon, N. C.
Pratt, J. H., State Geologist.....Chapel Hill

Prouty, W. F., Prof. of Stratigraphic Geology, Univ. of North Car...Chapel Hill
*Randolph, E. E., Dept. of Chemistry, State College.....Raleigh, N. C.
Randolph, E. O.....College Station, Tex.
Randolph, Mrs. E. O.....College Station, Tex.
Rankin, W. S., State Board of Health.....Raleigh, N. C.
*Rhodes, L. B., Div. of Chemistry, N. C. Dept. Agriculture.....Raleigh, N. C.
Robinson, Miss Mary, North Carolina College for Women.....Greensboro
*Roller, A. F., Science Teacher, Raleigh High School.....Raleigh, N. C.
Ruffner, R. H., State College.....Raleigh, N. C.
*Satterfield, G. H., Trinity College.....Durham, N. C.
Saville, Thorndike, Assoc. Prof. of Engineering, Univ. of North Car., Chapel Hill
Seymour, Miss Mary F., North Carolina College for Women.....Greensboro
Shaffer, Miss Blanche E., North Carolina College for Women.....Greensboro
Sherrill, Miss Mary L., North Carolina College for Women.....Greensboro
Sherrill, Miss Mildred, Science Teacher, Henderson High School, Henderson, N. C.
Sherwin, M. E., State College.....Raleigh, N. C.
Sherman, Franklin, Entomologist, N. C. Dept. Agriculture.....Raleigh, N. C.
Shore, C. A., State Laboratory of Hygiene.....Raleigh, N. C.
*Shunk, I. V., 222 West Morgan St.....Raleigh, N. C.
Smith, J. E., Iowa State College.....Ames, Iowa
Smith, M. R., Science Teacher, High School.....Fort Mill, S. C.
Smith, S. C., Dept. of Chemistry, University of North Carolina.....Chapel Hill
Smithey, Ira W., Dept. of Chemistry, Univ. of North Carolina.....Chapel Hill
*Speas, William E., Dept. of Physics, Wake Forest College.....Wake Forest, N. C.
*Spencer, H., State College.....Raleigh, N. C.
Stiles, Dr. C. W.....Wilmington, N. C.
*Stuhlman, Otto, Jr., Assoc. Prof. of Physics, Univ. of North Car. ....Chapel Hill
*Sullivan, R. W., Dept. of Chemistry, Wake Forest College.....Wake Forest, N. C.
Taylor, C. C., State College.....Raleigh, N. C.
Taylor, Haywood M., Dept. of Chemistry, Univ. of North Carolina...Chapel Hill
*Taylor, W. F., Wake Forest College.....Wake Forest, N. C.
*Thies, O. J., Jr., Dept. of Chemistry, Davidson College.....Davidson, N. C.
Totten, H. R., Dept. of Botany, University of North Carolina.....Chapel Hill
*Vann, H. M., Dept of Anatomy, Wake Forest College.....Wake Forest, N. C.
Venable, F. P., Kenan Prof. of Chemistry, Univ. of North Carolina..Chapel Hill
*Wells, B. W., Dept. of Botany, State College.....Raleigh, N. C.
*Wells, Mrs. B. W., State College Sta.....Raleigh, N. C.
*Wheeler, A. S., Professor of Organic Chemistry, Univ. of North Car...Chapel Hill
Williams, C. B., State College .....Raleigh, N. C.
*Williams, J. H., State College.....Raleigh, N. C.
Williams, L. F., State College.....Raleigh, N. C.
Wilson, Donald B., Dept. of Farm Crops, State College.....Raleigh, N. C.
*Wilson, Henry V., Kenan Professor of Zoology, Univ. of North Car., Chapel Hill
*Wilson, R. B., Dept. of Biology, Wake Forest College.....Wake Forest, N. C.
*Wilson, R. N., Trinity College.....Durham, N. C.
Winston, Dr. Lula G., Meredith College, 124 E. Edenton St.....Raleigh, N. C.
Winters, R. Y., State College.....Raleigh, N. C.
Withers, W. A., Dept. of Chemistry, State College.....Raleigh, N. C.

*Wolf, F. A., Plant Pathology, State College.....Raleigh, N. C.
*Wright, Miss Eva K., North Carolina College for Women.....Greensboro
Total 133.

The following papers were presented at the meeting:

Age of Insects. Z. P. Metcalf. (Presidential address.) Appears in full in this issue.

The Genus Raspailia and the Independent Variability of Diagnostic Features. H. V. WILSON.

Appears in full in this issue.

Current Research in Organic Chemistry at the University of North Carolina. ALVIN S. WHEELER.

Active work is being done upon six research problems. First, the nature of kelp oil from the distillation of kelp, a seaweed in the Pacific Ocean, is being investigated. Nothing whatever about it is known. Second, the bromination of 2-Amino-p-cymene yields a mono-bromo derivative and new compounds derived from it have been prepared. Third, the chlorination of 2-Amino-p-cymene also yields a chlorine derivative. The constitution of the two halogen compounds presents a fine puzzle in orientation. Fourth, further work is being done with Tribromojuglone as raw material. Fifth, the chlorination of juglone proceeds differently from the bromination and good results are being obtained. Sixth, a shorter process of obtaining bromo-amino-cymene is being sought, by brominating nitrocymene and then reducing. My assistants in these studies in the same order as the problems above are: H. M. Taylor, I. W. Smithey, I. V. Giles, T. M. Andrews, P. R. Dawson, S. C. Smith.

Some Fungi New to North America or the South. W. C. COKER.

Sirobasidium sanguineum, another species of a rare genus of gelatinous fungi which has been known before only from South America, has been found here. The author has previously reported *S. Brefeldianum* from Chapel Hill.

A remarkable form of a well known edible mushroom, the early *Pholiota* (*P. praecox*), occurs in Chapel Hill and Raleigh. It is distinguished by the absence of any visible trace of a veil. This would entirely mislead one as to its real place in classification, as the veil is supposed to be a generic character.

The only species of the mushroom genus *Tricholoma* (*T. venenata*) that is known to be poisonous was collected at Chapel Hill in the fall

of 1919. This has been known before only from Michigan, where it made seriously ill seven people who ate it.

A peculiar little mushroom of the genus *Lepiota* (*L. caerulescens*) which turns a deep indigo blue all over when it dries has been found here. It has been known before only from Missouri and Ohio.

Apodachlya brachynema, a minute but interesting and very rare mold growing on dead insects in water, has recently been found in Chapel Hill. It has been reported only once before from America, in Massachusetts.

Notes on the Oecology and Life History of the Texas Horned Lizard. J. P. GIVLER.

To appear in full in a later issue.

Artificial Incubation of Turtle Eggs. BERT CUNNINGHAM.

Chrysemys picta Herm. is recognized as a good species. *C. marginata* Agassiz, *C. cinerea* Bonnaterre, and *C. bellii* Gray are all included under the specific name of *C. cinerea*. *Chrysemys oregonensis* Nuttall, is also provisionally included under *C. cinerea*.

In some of the experiments eggs laid in the usual manner were used, but the majority of eggs were taken from the uterus. The latter showed a higher developmental rate. The fundamental requirements are proper moisture and temperature, and in the case of laid eggs they must be secured within a few hours of laying. Development may be stopped by low temperatures for a period of a month at least, and development of such eggs seems to proceed in a natural manner when brought back to a normal temperature.

The artificial incubation allows one to keep a record of the incubation time and thus secure a more graded series than is possible under natural conditions. It also makes possible much experimental work on the rate of development, inhibitors and activators.

Some Considerations in Defense of the General Biology Course. J. P. GIVLER.

To appear in full in a later issue.

An Interesting Anomaly in the Pulmonary Veins of Man. W. C. GEORGE.

In one of the anomalies found this spring in the anatomical laboratory at Chapel Hill the blood from the upper left lobe of the lung was drained not into the left atrium but into the systemic circulation. A

vein about a centimeter in diameter emerges from near the middle of the ventral surface of the upper left lobe and courses directly cephalad to empty into the left innominate vein. A short distance before it empties into the innominate this vein receives the accessory hemi-azygos vein. The right pulmonary veins and the pulmonary vein from the lower left lobe communicate with the left atrium as usual.

Alfred Brown (Anatomical Record, 1913) has shown that the pulmonary system in the cat arises from an indifferent splanchnic plexus in the region of the lung bud. This plexus has venous connections on the one hand with the sinus venosus and on the other with neighboring systemic veins (cardinals, segmentals, and others). Conditions similar to those shown in the anomaly cited apparently arise as a result of some interference with the return of blood through the pulmonary portion of the embryonic plexus thus causing both pulmonary and bronchial blood to enter the bronchial veins and causing their great enlargement. In this particular case then the large vein draining the upper left lobe seems to represent the enlarged left bronchial vein and that portion of the accessory hemi-azygos between the innominate and the junction of the left bronchial with the accessory hemi-azygos. Due to the enlargement of the bronchial vein the accessory hemi-azygos appears to be a side branch of it.

A More Phenomenal Shoot. WILLIAM F. PROUTY.

At the last meeting of the North Carolina Academy of Science Dr. B. W. Wells described "*A Phenomenal Shoot*" which grew near Raleigh during the season of 1919. This shoot "grew from the stump of a beheaded tree of *Paulownia tomentosa.*" The shoot described by Dr. Wells was 7.75 inches in circumference at the base, had 20 internodes and was 19½ feet in length. This shoot was supposed to have grown in one season, though this fact was not definitely known.

During the past season the writer has witnessed the development of a shoot from a tree of the same species cited by Dr. Wells which surpasses in its dimensions the one above referred to. This shoot grew during this past season to a height of 21½ feet. It has a circumference at base of 10 inches and has 24 internodes. One of the leaves, measured in the latter part of July, was 38 inches in largest dimension. This shoot grew in a clay-loam soil, residual from granite, on property adjoining the Campus, in Chapel Hill.

The following papers were read but no copies or abstracts furnished:

A Photometric Study of the Fluorescence of Iodine Vapor. W. E. SPEAS.
Breeding Results from Overwintering Cocoons of the Polyphemus Moth. C. S. BRIMLEY.
New North Carolina Gall Types. B. W. WELLS.
Solid Culture Media with a Wide Range of Hydrogen and Hydroxyl Ion Concentration. F. A. WOLF and I. V. SHUNK.
Judgments of Length, Mass, and Time. A. H. PATTERSON.
Effects of Desiccation on Cotton Seeds and on the Seed-borne Element of Cotton Anthracnose. S. G. LEHMAN.
Chlorination with the Silent Electrical Discharge. PAUL GROSS.
The Electron, its Measurements and Applications. J. B. DERIEUX.
Some Questions Concerning the Teaching of Physics in North Carolina. C. W. EDWARDS.
Questions Arising from the Discovery of Occasional Vertebrate Hermaphrodites with a Demonstration of a Case in a Pig. HARLEY N. GOULD.
The Anatomy of Angiopteris. H. L. BLOMQUIST.
Further Studies on the Pure Culture of Diatoms. BERT CUNNINGHAM and J. T. BARNES.
Aphidius, a Parasite of the Cotton Louse. H. SPENCER.
Notes on the Salamanders of the Cayuga Lake Basin, N. Y., with Reference to Eggs and Larvae. JULIA MOESEL HABER.
A Method of Differentiating Mucous and Serous Cells. EVA GALBRAITH CAMPBELL.
Recent Views on the Nutritive Qualities of Milk. J. O. HALVERSON.
Relationship of Temperature and Relative Humidity to the Distribution of Cockroaches. VERNON R. HABER.
From Egg to Frog in two Months. H. V. WILSON.

The following papers were read by title only, in the absence of their authors:

On the Polyembryonic Development of the Parasite, Copidosoma gelechiae. R. W. LEIBY.
The Lorentz Transformation in Einstein Relativity. ARCHIBALD HENDERSON.
The Inheritance of Economic Qualities in Cotton. R. Y. WINTERS.
Notes on Recently Discovered Miocene Whale. WILLIAM F. PROUTY.

The following paper was transferrred to the Chemical and Physical program:

Ionizing Potentials of Gases by Negative Electrons. A. A. DIXON.

C. S. BRIMLEY, *Acting Secretary.*

JOHN FRANCIS LANNEAU
1836–1921

A long and variously distinguished career came to a close when John Francis Lanneau died in Wake Forest, March 5, 1921. He was born of Huguenot parentage in Charleston, South Carolina, February 7, 1836. His father was Charles Henry Lanneau, his mother, Sophia Lanneau. He was graduated from the South Carolina Military Academy in 1856. His teaching career began at once in 1857 as tutor in mathematics, and from 1858 to 1861 as professor of physics and chemistry, in Furman University, Greenville, S. C. Then came the Civil War in which he served four years first as Captain of cavalry in Hampton's brigade, later as Lieutenant and Captain of engineers. At the conclusion of the war he resumed his connection with the Furman faculty, being professor of mathematics and astronomy from 1866 through 1868. For the next four years he was professor of mathematics in William Jewell College of Missouri. In 1873 he accepted the presidency of the Alabama Central Female College, Tuscaloosa, holding that position for six years. From 1879 to 1888 he was president of the Baptist Female College, Lexington, Missouri. The next two years he was president of the Pierce City Baptist College of the same state. In 1890 he accepted the professorship of physics and applied mathematics in Wake Forest College. From 1899 to his death he was professor of applied mathematics and astronomy.

The honorary degree of M. A. was conferred upon him in 1869 by Baylor University, LL. D. in 1915 by Furman University.

Of striking physique and courtly bearing Dr. Lanneau won attention and respect wherever he appeared. He was of the finest type of the Christian gentleman and up to the day of his death was chairman of the board of deacons and treasurer of the Wake Forest Baptist Church.

Apart from the immediate tasks of the class room, Dr. Lanneau showed his deep scientific interest in several ways. He was probably the first man in North Carolina to give demonstrations and public lectures on the X-rays. In 1907 he invented the Cosmoid manufactured by Wm. Gaertner & Co., of Chicago, and described by him in "Popular Astronomy," December 1913. It is an ingenious apparatus for illustrating many astronomical conceptions and motions.

It is capable of numerous and easy adjustments. He was an active member of the North Carolina Academy of Science and of the Astronomical Society of the Pacific.

A list of his scientific papers is appended:

The Source of the Sun's Heat. Popular Astronomy **14**: 410. 1906. Also published in Journ. E. M. Sci. Soc. **22**: 45. 1906.

The Sparsity of The Stars. Popular Astronomy **15**: 390. 1907.

Sirius, the Bright and Morning Star. Popular Astronomy **19**: 393. 1911.

The Cosmoid. Popular Astronomy **21**: 613. 1913.

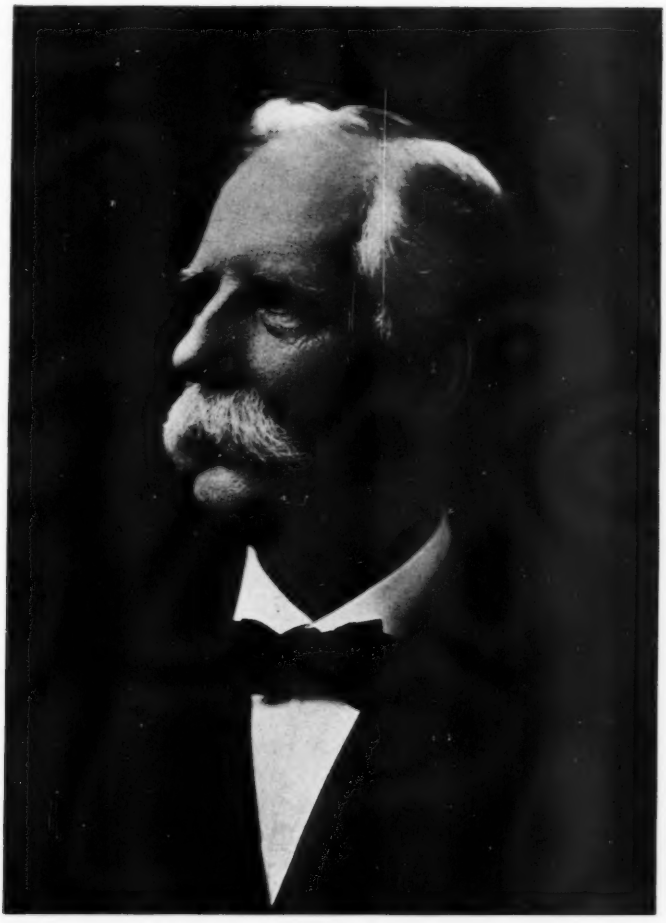
The Sun's Eclipse of June 8, 1918: Question. Popular Astronomy **26**: 299. 1918. Also published in Journ. E. M. Sci. Soc. **34**: 76. 1918.

Sunspots in July, 1903. Popular Astronomy **11**: 372. 1903.

Physics of Shooting Stars. Popular Astronomy **13**: 434. 1905.

Approaching Sun-Spot Maximum. Journ. E. M. Sci. Soc. **20**: 21. 1903.

WM. LOUIS POTEAT
CHARLES E. BREWER,
H. V. WILSON.



JOHN FRANCIS LANNEAU
1836–1921

THE AGE OF INSECTS.

By Z. P. Metcalf

Geologists are in the habit of speaking of this as the "age of man" or the Psycozoic era. From this stated opinion I wish to dissent, for this evening at least, and call your attention to the fact that while we as humans may speak of this egotistically as the "age of man" it is not the age of man but the age of insects in which we are living. Man may try to dominate this age but on every hand he finds his efforts thwarted and at every point he must give way to numerous hordes of insects whose chief aim seems to be to overthrow the kingdom of man on this world. The late unpleasantness in Europe is remembered by our soldiers, not so much as a war on the Boche, as a war on innumerable insect pests denominated cooties. And even those of us who had no chance at first-hand knowledge can sympathize with the young Canadian who, when he was decorated with some medal or other for outstripping his fellows in a charge, remarked that his interest in the matter was not in the charge but in the hope that he could run fast enough and far enough to escape the cooties.

As in war so in peace, on every hand we find our lives circumscribed and our efforts limited because of the presence of numerous insect pests. Our crops, our domesticated animals are increasingly subjected to their attacks. Our forests are devastated by them. Our houses and our stores are destroyed by them. Our books and our paintings are marred by them. Whole regions of the world are practically unfit for human habitation because of the diseases they carry, and human want and human suffering abound in all quarters because of these troublesome little pests. In fact, they have so adapted themselves that it is impossible to think of any relation of human life and human culture that is not colored in some way by insects, yea even as pointed out below our very existence is dependent upon them.

It would seem logical, therefore, that anything that touches us so vitally ought to be pretty well understood. Yet, I believe I am safe in saying that there is no group of animals so little known, to zoologists even, as insects. This in spite of the fact that more of our zoological literature, each year, is devoted to insects than all other animals combined. Whole regions of the insect kingdom are still unsurveyed and, while we know a little about the external anatomy of a few forms, our knowledge of the internal anatomy is still largely based on the

work of Swammerdam in the seventeenth century, who worked without a compound microscope or a microtome. Our knowledge of the ecological relations is largely based on superficial studies of the life histories of isolated species and all the rest is sweeping generalizations that are almost certain to fail in the acid test of real ecological experiments. Our knowledge of insect vectors of human, animal, and plant diseases are equally poorly grounded on the knowledge that the tsetse fly carries sleeping sickness, that the malarial mosquito carries malaria, that the cattle tick (not an insect) carries Texas fever, and a few other cases from which we generalize often wisely, if not too well.

We are often guilty of orating, sometimes rather loudly, I am afraid, about the damage done by the gypsy moth, or the boll weevil or what not, but do we even stop to ask ourselves about the remarkable interplay of physiological processes between plant and insect or the ecological relations between the insect and the host of conditions that surround it? And the echoes answer, "Do we?"

If this then is the condition among our professional zoologists (I believe entomologists are still regarded as zoologists by the layman, if not so regarded by his fellow zoologists), what is the condition among other scientists, and other folks in general,—that great class to which we scientists refer frequently, and not without condescension, as the lay minds, as something separate and entirely distinct from our minds which are denoted as academic minds. It is in the hope that I may be able to educate the lay mind that this paper has been prepared. And for fear that some of you may miss the drift of my remarks, I hasten to remind you that you are the lay mind, and to add that I am not exactly clear as to just why you are the lay mind or just what makes my mind, entomologically speaking, an academic mind, while from the standpoint of the chemist or the physicist or the botanist or what not my mind is removed from its temporary and somewhat insecure pedestal and is laid at the base and becomes perforce a lay mind. Perhaps I would feel just as well and you would have more respect for what I have to say if I did not inquire too closely into this phase of the subject but hasten on to tell you something about bugs, as I see that you are all sitting somewhat breathlessly with open mouths, if not with open minds, to learn something about this field that we call entomology and about this age that we call the age of insects.

Before I proceed, however, I must warn you that I am not an entomologist, let alone a zoologist, although I believe that is the title

that is conferred upon me by powers vested in the State of North Carolina and the government of these United States, but a specialist in an obscure group of insects. I tell you this to defend myself against the hordes of specialists in other groups who may hold up their hands in holy horror at some of the generalizations that I may make. Now the specialist is a sort of rare bird whose words are a law unto himself, at least, and who knows so much about his own pet field that he knows nothing about anything else and his final defense in all arguments about his field is, "Well, I am the specialist in this group." To which some of you, who are broadly academically minded if not lay minded, must feel like exclaiming, "We are thankful for that much at least." The difference in those things is of course one of degree. For instance a student of insects is, naturally, an entomologist but a student of fleas is a Professor of Suctoria, the student of the hind leg of a flea is a pulicidid morphologist and the student of the hairs on the second joint of the hind leg of a flea is a specialist and I say it reverently, "May the Lord help him!"

With this rambling and somewhat generalized introduction, you will pardon me if I turn your attention to some of the various aspects of the insect world in order that we may examine them more closely. Emerson said something to the effect that fools are amazed at the extraordinary and wise men wonder at the ordinary. I shall presume therefore on your wisdom and use only ordinary examples with which to paint my picture of the insect world.

THE NUMBER OF INSECTS IN THE WORLD

The possible number of insects in the world has always been a subject of very great interest to me. I, of course, refer to the number of kinds or species not to the number of individuals. No one has been foolhardy enough to make a personal census of insect individuals as yet, I believe. The nearest approach to this are the statements that misguided sanitarians and others make, sometimes, to the effect that starting with a single pair of houseflies we would have, by the end of summer, so many quintillions of flies. We all know this is not true, save perhaps on a summer afternoon when we are trying vainly to get our allotted forty winks and all but succeeding because of several of the above mentioned quintillions that persist in lighting just to the windward of an upturned nose. Or there is the statement that starting with a single plant louse, with all of her descendants surviving, we

would have, in a year or two, a mass of plant lice equal in volume to our earth. This may or may not be true, but if true a large proportion of the descendants must fly away to other worlds than ours because any species is lucky indeed if it ends its fiscal year and balances its books with a definite increase in numbers over the previous year.

The question of the number of species of insects is, however, another matter. We see, in our text books, estimates of the number of species of insects in the world, at anywhere from 250,000 to 500,000 and 1,000,000 and recently some one ventured to estimate that there must be at least 10,000,000 kinds of insects in the world, at the present time.

Obviously, in trying to generalize about a group of animals with such an enormous number of species, one finds himself handicapped not from lack of material but from its very superabundance.

General Physiology.

Typically, an insect is an arthropodous animal with its body divided into three parts; head, thorax and abdomen, and with three pairs of legs and usually two pairs of wings. Being an arthropod, an insect carries his skeleton on the outside of his body and as he grows this skin which is hard and chitinous must be cast off and a new skin produced to accommodate the larger sized individual. This skeleton is segmented to provide free movements. Thus various parts have been separated and since these parts are fairly constant they have been much used in taxonomy. But their phylogenetic relations are not always clear and thus a special nomenclature has grown up around each group which has served to discourage all but the most highly specialized of the specialists and has acted as a sort of natural selection, thus cutting down materially the crop of specialists, much to the general benefit of the world at large. With these special parts we need not concern ourselves here but the generalized parts will bear closer inspection. The head is largely sensory in function and bears the compound eyes, simple eyes and antennae. These will be discussed more in detail under sense organs. The head also bears the mouth parts which are among the most complicated structures found in the animal kingdom. Primitively, they consist of no less than three paired and three unpaired structures. We cannot inquire into the various morphological variations but the following classification of the mouth parts of insects based largely on functional grounds will

perhaps aid in conveying the complexity of the subject. We have, as our most generalized, the chewing insects which are fitted with a pair of mandibles which tear and masticate food.

A scraping type which lacerates the epidermis of plants and sucks up the exuding sap.

A piercing type in which the mouth parts are fitted for piercing the skin of an animal or the epidermis of a plant and sucking the blood or sap.

A rasping type fitted for rasping off solid particles and dissolving them in saliva and then sucking up the resultant liquid.

A sponging type in which the mouth parts are fitted for sponging up exposed liquids.

A siphoning type in which the mouth parts are formed into a long hollow tube which is usually used to suck up exposed nectar.

A lapping type in which the mandibles are well developed for working wax and paper or for portage and the other mouth parts are modified into a tongue which is used to lap up exposed liquids.

The thorax is largely given over to locomotion, which is carried on by the wings and legs. The insects were without doubt the first animals to conquer the air and of all animals, birds not even excepted, their mastery of the air is the most complete. The legs are fitted chiefly for walking, running, leaping and grasping. The speed of certain of our insects is indeed remarkable, as is their ability to make surprising leaps. The world's record for the broad jump is not held by a man but undoubtedly belongs to the flea. A leap of a hundred times his length would be no astounding feat for a flea, whereas for man five or six times his length would be wonderful indeed. In the same way the muscular strength of insects is almost beyond belief. The weakest insects according to Plateau can pull five times their own weight, while the average is more than twenty times, and one of the leaf beetles can pull forty-two times its own weight. In contrast man cannot pull his own weight and under the same conditions a horse could pull but three-quarters of his weight. Some of the insects are able to push one hundred times their own weight, while the honey bee can carry a load equal to three-fourths of its bodily weight. These remarkable feats are accounted for by the small size of the insects and by the greater advantage in leverage from an external skeleton.

Passing to the internal organs we find time for the discussion o two systems of organs only. The first of these is the respiratory or

gans or trachea. The insects differ from man in that their circulatory organs are very poorly developed and their respiratory organs are well developed to counterbalance this. The insects have no lungs but a system of trachea or tubes which open to the exterior through minute pores called spiracles. From the spiracles the trachea branch and rebranch until they reach all parts of the body. The oxygen is carried to the cells through these tubes and the carbon dioxide carried away through the same set.

The nervous system and sense organs of insects are so different from those of man that we are often at a loss to account for the sensory life of insects. There is in the insects no brain as we find it in the vertebrates but the nervous functions are distributed to a chain of ganglia along the ventral wall of the body. There is therefore more or less of local control for each region of the body. The psychic life of such animals is therefore rather low and in no way to be compared with that of man.

The sense organs of insects may be grouped into three classes (Comstock):

Mechanical sense organs.—Touch and hearing.

Chemical sense organs.—Taste and smell.

Organs of sight.

Touch organs are generally distributed over the body and need no special discussion. Organs of hearing are apparently not universally present. They occur among the singing orthoptera and in mosquitoes and perhaps in bees, but whether they occur in other forms is by no means clear. In the grasshopper the ears are located on the first segment of the abdomen, but in the katydids and crickets they occur on the tibia of the fore legs. In the mosquitoes they undoubtedly occur on the antennae, as the antennae are provided with whorls of setae which gradually decrease in length from the base of the antennae outward. It has been demonstrated that these setae vibrate to notes of different pitch and it is believed that the vibrations are transferred to the nerve endings. Most beekeepers believe that bees can hear because they make such different hums under different circumstances, and even an amateur can tell the difference between the busy hum, the swarming hum, and the angry hum of an outraged bee.

The chemical senses of insects are very poorly understood. This is due in part to the wide distribution of these organs over the body and to the fact that several different types of sense organs are frequently closely associated. We say that insects taste because we

know they make selections in foods, and we say bees smell because they seem to be able to distinguish members of their own colony from other bees, and they seem to be able to recognize their queen and to distinguish drones.

The sense of sight in insects is taken care of by two distinct types of eyes, the simple eyes and the compound eyes. The former we believe is used chiefly to distinguish light from darkness while the latter is used to give an image. The compound eyes of insects are composed of from a few to many hundreds of hexagonal prisms, called ommatidia. It is believed that each ommatidium forms a portion of the image just as tiles are put together to form a mosaic. Or, since the ommatidia are hexagonal in shape, perhaps we can best compare the image that insects receive to the image our eyes receive when we look through a piece of glass which has been laid down on poultry netting. Each mesh of the poultry netting would contribute its portion to the image just as each ommatidium of the insect's compound eye does. Obviously such an eye is better adapted to seeing motion than it is to seeing distinct images.

INSECT PSYCHOLOGY.

I wish I had the agile mind and the facile pen of a Fabre so that I would be able to unfold for you some of the beauties of the instincts of insects. We may see striking illustrations on every hand. Why do certain insects always lay their eggs in such situations that their young will find an abundance of food at hand? This question is of course easy to answer in the cases of those insects whose adults feed on the same plants as the young. It is simply a matter of placing them in the most convenient place; but we are confronted with the query, why do some of these insects take such elaborate pains to conceal their eggs by placing them in the stems of plants or imbedding them in the tissues of the leaves? On the other hand we are confronted by that vast host of adult insects which lay their eggs on food plants or animal hosts upon which they themselves do not feed. Or we are confronted by that complicated set of reactions, so well illustrated by our solitary wasp, where a nest is constructed and prey is searched out and stung in the precise spot to paralyze the individual but not cause its death. Then the prey is dragged back to the nest and stored with an egg and the nest closed and concealed. Or we see an insect like the cornfield ant taking the eggs of the corn and cotton root louse into its

nest and storing them through the winter, shifting their position in its tunnels with the changes of the temperature so that it will not be injured, then hatching the egg in the sun in the spring and placing the young nymph on the proper food plant. All this in order that the ants' descendants may have an abundant supply of honey dew for their nourishment. What are the mental processes of the eumenes wasp as it fashions the clay into pottery of the most charming design—a design so artistic that man has copied it as his very own. What are the mental processes of the tiny caterpillars as they weave their marvelous gossamer threads and become the earth's first aeronauts? What are the fungus ants thinking about as they prepare a fertile field and sow upon it the spores of a certain species of fungus in order that their children may have an abundance of food? What of the mental processes of the scarab as it rolls its ball of dung often many weary insect miles in order to provision its nest for its larva? Why does each species of scarab store its nest with the dung of certain animals only? What is the psychological process of the queen bee that causes her to lay only unfertilized eggs in drone cells? What are the slave-making ants "thinking about" when they make a raid on the nest of another species, kill the adults, kidnap the larvae and pupae, carrying them away to their nests where they are raised to adults to serve their captors?

We see these questions about us every day and we ask the question "Why?" and we reply very wisely with the magical word "instincts." Which is a very learned and very scientific way of saying that we know nothing about it.

In ordinary speech, the word "instinct" stands for all the hereditary and automatic revelations of activity, from simple tropisms to the most complicated outward manifestations of individual memory. Instinctive acts are stereotyped, being ever the same when responding to stimuli of the same nature, and almost always adapted to their object, although not resulting from previous experience on the part of the individual. To define them more precisely is impossible for they are varied and complex, overlapping one another and often becoming so confused as to render difficult the tracing of their limits. Nevertheless, we should not place them all on the same level and attribute to them all a common origin. Tropic reactions are due to the properties of living matter, rhythms presuppose an organic memory and hence a period of education, ancient or recent; but this apprenticeship is purely mechanical and dependent upon the stimuli that produce it.

Apprenticeship has its part also in those manifestations of memory belonging to the species which play such an important part in the behavior of arthropods. This kind of memory presents a character of distinct superiority, inasmuch as it was made effective for the race by the distant ancestors of the individual in the guise of a choice between the various possible responses of differential susceptibility. Choice, of a remarkably intellectual nature, is even more noticeable in the instinctive manifestations of individual memory. The animal, endowed with well-developed senses and nervous system, not only reacts to new necessities by new acts, but associates the stored impressions of new sensations and thereby appropriately directs its further activities. Thus, by an intelligent process, new habits are established which by heredity become part of the patrimony of instinct modifying the latter and constituting elements essential to its evolution. Of these instincts acquired through an intelligent apprenticeship Forel was led to say that they are reasoning made automatic and it is to them particularly that we may apply the idea of certain biologists that instincts are habits which have become hereditary and automatic. Probably all superior instincts at first had this intellectual quality. This certainly is true of all such as originated from more or less slowly acquired habits; it seems to be the rule as well with instincts due to mutations. It stands to reason that, whether they result from a sudden psychic change or from a sudden organic modification, these instincts must always be preceded by some intelligent period of education, during which they become perfected, in order to be handed on to posterity and to assume the character of true instincts.

Here, then, we are confronted with several classes of instinctive acts, which differ not only in origin but also in intellectual characteristics. No doubt they are linked together by many intermediate manifestations, and in the animals with which we are now concerned they often blend the one with the other or even with the reflexes, on account of the profound differentiation of nervous and sensorial centers. It is, nevertheless, very difficult to consider them as manifestations of a special faculty which we would fain place on the level of intelligence by calling it instinct. The name instinct justly applies to certain forms of activity which are innate and automatic, but these forms proceeded in diverse ways from the vital energy which is the source of all organic activity, and the highest of them, which are at the same time the most striking ones in the animals here studied, were originally acts more or less requiring the exercise of true intelligence on the part of

species and individuals. Intelligence has no part in the development of the instinct that draws nocturnal Lepidoptera toward the light, nor has it doubtless anything to do with the rhythms through which organic memory manifests itself. But intelligence it is that regulates by appropriate selection all manifestations of race memory; intelligence again in the sundry forms of association and individual memory, that puts together the most complicated mechanisms of instinct.

Instincts are of various kinds. If, by the word instinct we understand not any one special faculty but the complex of all the instincts, namely, the innate automatism regardless of its origin, we can say with Bergson that instinct and intelligence "are not things belonging to one and the same order," that they "diverge in direct ratio of their development," but that "they never become completely separate." They are both "opposites and complements" and they assist one another. "On the one hand, indeed, the most perfect instincts of the insects are accompanied by certain gleams of intelligence, be it only in the choice of place, time or material of construction. When by exception bees build their nest in the open they invent arrangements which are new and in the true sense intelligent to meet the new conditions. On the other hand, intelligence has still more use for instinct than instinct has for intelligence, since the ability to work up raw material presupposes in the animal a superior grade of organization, to which it could have arisen on the wings of instinct only." Before such evidence as this Fabre was forced to modify his theory of immutable instinct. "By itself, mere instinct," says he, "would leave the insect disarmed in the perpetual conflict of circumstances. A guide is needed in the midst of this bewildering mêlée. That the insect has such a guide is evident to a high degree. This is the second domain of its psychic powers. Here it is conscious and susceptible of perfecting by experience. As I dare not designate this rudimentary aptitude by the name of intelligence, a title too noble for it, I shall call it discernment." But is discernment in this sense not really a form of intelligence?

Such is the measure in which instinct and intelligence are combined in animals. If, following Bergson, we admit that consciousness "is proportional to the power of selection at the animal's disposal," it will be quite evident that consciousness must be particularly obscured in all purely instinctive acts, but that on the contrary it must accompany all intelligent acts. Bergson, however, regards consciousness in a peculiar light, since he considers it as "life projected

through matter," as the common source from which sprang in different directions both instinct and intelligence. This view leads us away from the commonly accepted theory that consciousness must be considered as that inmost luminary which enlightens our actions. It is possible, even probable, that this kind of consciousness exists to a greater or lesser extent in the animals. However, we can not know anything about it, and we believe with Ed. Claparede that "the science of animal psychology may and must scrutinize the problem of the greater or less intelligence of animals without being concerned about their consciousness."

We discern intelligence in its simplest expression wherever we notice a choice between the various alternatives offered by circumstances, and in one of its highest forms wherever we observe that power of invention which, according to Bergson, enables the human race to "manufacture artificial objects, more particularly to make tools with which to make other tools and to vary their fabrication indefinitely." These two extreme forms are naturally connected by a series of links, and we know that the one as well as the other plays a part in the behavior of arthropods. The latter of the two seems, however, to be rather exceptional in our group, showing itself only in the primitive state consisting of the use of foreign bodies as implements. The tool used by Ammophila is a small stone with which the female rams and packs the dirt that closes her burrow. With certain ants of India (*Oecophylla smaragdina*) and of Brazil (*Camponotus texter*) the instrument consists of the larva of the species itself. Held between the mandibles of the workers, these larvae, by means of their thread, glue and fasten edge to edge the leaves of which the nest is constructed. The implement of the crabs, of the genus Melia, in the Indo-Pacific seas, is supplied by a delicate sea-anemone. This is held between the pincers of the animal, which probably uses the nettling exudations to paralyze its prey.

Facts of this nature are rare in the world of arthropods, but they have an important significance. The use of the little stone is not yet a fixed habit with Ammophila, it belongs only to certain individuals more highly endowed than others and is perhaps only accidental even with them. Maybe it will finally pass into the instinctive habits of the species; for the present it belongs to the domain of individual intelligent acts. The crabs of the genus Melia are already farther advanced, all the species carry anemones and all exhibit a curious modification of the pincers, the fine teeth having become elongated and

needlelike so as to give them a better hold on their guest and tool. That they are adapted to the latter is evident, yet this adaptation is not such that the crab is likely to be in serious danger when it has not its Actinia. Many of the Melias brought back by explorers are not provided with anemones, and we may believe that the presence of this implement guest is not yet of vital importance to the species of this peculiar genus. The case of the ants which use their larvae as needles is quite different. With them this singular habit is innate and specific. Though probably acquired through intelligent acts, it now belongs entirely to the domain of instinct in the species among which it prevails. And thus we always come back to that predominating fact of the psychological history of arthropods, namely, the transformation of intelligent acts into instinctive acts. The following considerations formulated by Bergson eminently apply to this group:

Among animals, invention is never more than a variation on the theme of routine. Locked up as it is within the habits of its species, the animal succeeds no doubt in broadening these by individual initiative; but its escape from automatism is momentary only, just long enough to create a new automatism; the gates of its prison close as soon as they are opened; dragging the chain merely lengthens it. Only with man does consciousness break the chain.

Man occupies the topmost place in the scale of vertebrates, for, breaking the bonds of instinct he insures thereby the complete expansion of his intellect. Insects especially Hymenoptera hold the same dominating position in the scale of arthropods where they are the highest achievement of instinctive life. These two groups represent the actual extremes of the two paths followed by psychic evolution in the Animal Kingdom; the arthropods are going toward instinct, the vertebrates toward intelligence. These two courses are quite opposite, but why have they diverged? At the beginning of their evolution, during that far distant epoch when they were differentiating along four main lines (echinoderms, mollusks, arthropods, and vertebrates), animals were threatened by a great danger—"an obstacle" says Bergson, "that doubtless almost checked the progress of animal life. There is a peculiarity which we can not help being struck by when we glance at the Paleozoic fauna. The mollusks at that time were more universally provided with shells than those of today. The arthropods in general were provided with a carapace. The oldest fishes had a bony covering of extreme hardness." But "the animal which is shut in a fortress or in a coat of mail is condemned to an exist-

ence of half-sleep. It is in this torpor that the echinoderms and even the mollusks are living today. The arthropods and vertebrates escaped from it and on this happy circumstance depends the present development of the highest forms of life.

"In two directions, indeed, do we see the impulse of active life regaining the upper hand. The fishes exchange their ganoid armor for scales. Long before them the insects had made their appearance, having also rid themselves (of most) of the armor that once protected their ancestors. In both groups the inefficiency of the protective envelope was compensated for by a nimbleness that enabled them to escape their enemies and also to take the offensive and to select the place and time of the encounter."

These remarks rest on a solid foundation but they should be modified in one particular which is of paramount importance in the explanation of the structure and the special psychology of the arthropods. These animals have never lost the chitinous armor that protected their primitive ancestors. They have preserved it in its entirety and with greater or less thickness. Coleoptera, crabs, scorpions, and thousand-legs of our times are by no means inferior in this regard to the ancient forms from which they are descended.

As a matter of fact they are covered today, as in times of yore, with an external skeleton of chitin. That is why Edmund Perrier, in his desire to emphasize their dominant character, has called them Chitinophores. To escape imprisonment within their protective envelope, to acquire the flexibility and mobility necessary to their evolution, they underwent certain superficial modifications. These consisted in the division of the armor into several pieces by means of articular lines, along which the chitin is less thick than elsewhere, thus allowing the pieces to move one upon the other. This is the very way in which they became arthropods, at once acquiring agility without losing their protective cover. Naturally such joints were formed wherever the several segments, arranged in a row and constituting the body of the animal, came together. As a result, these segments acquire a certain independence and their uniformity is to a certain extent preserved. Indeed, we see that many arthropods possess a pair of appendages on each segment (Myriapods and the majority of Crustaceans) and that the insects most remote in this regard from the primitive types are still provided with seven pairs of appendages (one pair of antennae, three pairs of buccal appendages and three pairs of legs) not to speak of the modified or rudimentary organs to be seen on

the different parts of the abdomen. And the chitinous envelope of these appendages has broken into joints in the same manner in which the body itself became annulated. Hence the name of arthropods which is given to these animals.

What a difference from the vertebrates. Their skeleton becomes an internal framework. The organism is thus allowed to attain greater dimensions; the segments are able to fuse to a greater degree and to lose more or less their independence; all of which results in the reduction of the number of limbs to only two pairs.

Now, the relative independence of the segments and the multiplicity of the appendages have as a corollary the differentiation of these structures, each of which plays a special part in the organism. As Bergson remarks, the various appendages of arthropods are as it were natural implements, which differ from each other in structure as well as in function. Their specialization may be carried so far as to have each part of a single organ perform a separate function. This is clearly seen in the bee, in which the first tarsal joint of the hind legs is transformed into a brush, the tibia into a pollen basket, while the two joints, by the contact of their edges, act as pincers which take up the flakes of wax secreted under the abdomen. It is an admirable instrument wonderfully adapted to the performance of its particular tasks. As a general rule, apart from the changes which they may undergo in the course of specific evolution, the appendages of arthropods are unchangeable in the individual and are narrowly adapted to certain purposes; they are the tools for instinctive work, and in this they differ from the less specialized but more generally useful limbs which serve as implements to the vertebrates, at least to the higher vertebrates. With these latter, as Bergson expressed it, the two pairs of limbs "perform functions much less strictly dependent upon their forms," acquiring complete independence in man, whose hand can do any kind of work.

"It seems, then, that the extraordinary preponderance of instinctive activity among the arthropods has as its essential reason the differentiation and the multiplicity of the appendages, in other words, the chitinization of the integument and the formation of joint lines which results from it. From the beginning these animals were doomed to use organic instruments, and they made the best use possible of these. Their main psychical task consisted in engraving upon their memory and in instinctively repeating the acts to which these organs were adaptable." (Bouvier.)

Or we follow a bee as it leaves its hive and visits flower after flower and when it has gathered its load of sweets it takes a "bee line" for the apiary and when it gets there it goes directly to its own home without any mistakes and we talk very wisely and knowingly about the "homing instincts of the bee," but do not be led into believing that we really know anything about it. Because I am afraid that about all we know is to laugh at the poor Swiss peasant who paints the fronts of his hives in fantastic design so that his bees will find the right hive. Perhaps he laughs best who laughs last and the Swiss beekeeper may be right after all. Who knows?

When we contemplate the marvels of colonial life among the insects and the paucity of our knowledge of the warp and the woof of the intricate pattern that they make, we are filled with admiration of the blind Huber who taught us so much of the psychology of the bee. The intricacy of the problem is appalling but when we consider the benefits that might accrue to the beekeeper by their solution we are more inclined to buckle down to work and renew our efforts to solve them.

No wonder we feel like exclaiming with Maeterlinck: "The insect does not belong to our world." The other animals, even the plants, notwithstanding their mute existence and the great secrets which they jealously guard, do not seem wholly strangers to us. In spite of everything we have a certain feeling of terrestrial kinship with them. They may surprise, nay, astonish us, but they fail to upset the very foundations of our concepts. The insect, on the other hand, displays something that seems incongruous with the habits, the morals, the psychology of our globe. Apparently it comes from another planet, more monstrous, more vigorous, more demented, more atrocious, more infernal than ours. Vainly does it seize upon life with an authority and a fecundity unequaled here below; we can not accustom ourselves to the idea that it is part of the scheme of that nature of which we fondly believe ourselves to be the favorite children. With this amazement and this failure to understand is mingled, no doubt, a certain instinctive and profound feeling of dread imparted by these beings so incomparably better armed and equipped than ourselves, these containers as it were of compressed energy and activity which we vaguely feel to be our most mysterious enemies, our final competitors, and perhaps our survivors.

LIFE HISTORIES.

The general phases of the life histories of insects are usually well known but even here we find that there are many popular misconceptions. McCormack tells of a physician who laughed at the notion that house flies are but one stage of maggots for said he, "Have I not often seen little flies coming out of the ground in the spring." One of our largest potato growers believed that I was trying to fool him when I told him the "soft shelled potato bug" is but the grub of the "hard shelled potato bug" and he was not convinced until he had tried the thing out and carried the grubs through their changes to pupae and then to adults. Afterwards he said to me, "That is the most valuable lesson I have ever learned on the farm, for it has taught me that I have not seen what is about me every day."

We are inclined to smile at the ignorance of people in general as outlined by such examples as those quoted above but before we allow our smiles to become too broad perhaps it would be better to inquire into our own knowledge. We know or think we know the life histories of a few insects scattered from one end of the insect kingdom to the other but this knowledge is based chiefly on the study of a few economic forms. And too frequently these life histories have been worked out in our more northern states and apply only imperfectly or not at all to our southern conditions.

The wonders in the adaptations for carrying on the life cycle of insects are almost beyond belief and I wish that I had the space to recount many of them but time will permit citing only a very limited number. The time involved in completing a life cycle is apparently as varied as the species of insects themselves. I need only remind you of the cicada on the one hand, whose cycle covers seventeen years, while on the other hand we have the house fly with a complete cycle every nine to fourteen days, in the warmer parts of the year.

The complexity of the cycle is also very much involved. We have insects like the fish moth with no changes or metamorphosis on the one hand while on the other we have forms like the blister beetles with no less than eight distinct stages in its cycle. Between these two extremes are all grades of forms with almost every conceivable relation.

The following table will make these relations clearer than they would otherwise be:

GROUP	EXAMPLES	PERIODS						
		INCUBATION	HATCHING	GROWTH*	SEVERAL MOULTS	TRANSFORMATION	REPRODUCTION	
Ametabola (with no metamorphosis)	Silver fish	Egg		Young		Wanting	Adult	
Paurometabola (with gradual metamorphosis)	Grasshopper Harlequin bug	Egg		Nymph		Wanting	Adult	
Hemimetabola (with incomplete metamorphosis)	Dragonflies	Egg		Naiad		Wanting	Adult	
Holometabola (with incomplete metamorphosis)	Butterflies	Egg		Larva		Pupa	MOULT	Adult

* It should be emphasized that the number of moults during the growth period varies endlessly in different species though usually the same in any given species.

Yet I am sure that these dry as dust facts cannot impress you with the wonders of insects' life cycles. Neither do they answer the thousand and one questions that you might ask in regard to this subject. In the first place we might ask why is there any metamorphosis at all? And our answer is of course an indirect one as all that we can do is to point out its all but universal occurrence among insects and to call attention to the fact that the groups without metamorphosis are simply a small remnant of what was perhaps a mighty race,— a race not in the direct line of the ancestry of the higher insects but a branch from that ancient worm-like tracheated ancestor of the insects. The advantages of such a metamorphosis are many. It leaves the nymph, naiad or larva, the growing period free to assimilate food and store up energy while the adult is given excellent powers of locomotion so that it may roam far and wide searching for suitable feeding grounds for the next generation.

But why weary you further by recounting these thrice told tales when a few minutes spent in watching a butterfly emerge from its chrysalis or a larva change to a pupa will bring you closer to nature and impress you more with the wonders of metamorphosis than anything I might say.

THE TAX TO INSECTS.

Entomologists, especially economic entomologists, in our experiment stations and departments of agriculture, appreciate, in a vague way at least, the annual loss occasioned by insects but the figures are so startling and so beyond the realm of our ordinary everyday financial dealings that they make little or no impression. For instance I made recently a rather careful estimate of the loss to the farmers in North Carolina last year caused by insects and was somewhat startled myself to find that it totalled no less than $84,750,000.00, as shown by the following table:

CROP	1920 VALUE in N. C.	PER CENT. LOSS	INSECT DAMAGE
Corn	$110,480,000	10	$11,050,000
Tobacco	97,130,000	20	19,425,000
Cotton	68,750,000	10	6,875,000
Hay	35,000,000	10	3,500,000
Truck garden and crop	77,500,000	20	15,500,000
Wheat	20,000,000	5	1,000,000
Fruit	50,000,000	20	10,000,000
Forage	48,000,000	5	2,400,000
Animal and Animal Products	200,000,000	5	10,000,000
Forests	20,000,000	5	1,000,000
Stored Products	40,000,000	10	4,000,000
			$84,750,000

Enough to pay our $50,000,000 road bill and have enough left in one year to pay the ill fated $20,000,000 six year program for our institutions of higher education with a paltry $14,750,000 left. But I fear that most of us are not in the habit of dealing in millions of dollars and that these figures make very little impression on us. Perhaps it would be easier if we look at this as a tax. As a tax this means more than $40 for every man, woman and child in our state annually. Certainly more than the average tax for all purposes, state, city, county and town. Or let us look at it in another way. An observant entomologist will tell you that in the average year our crops suffer anywhere from 5 per cent to 30 per cent depreciation from the attacks of insects. Some crops suffering much more than others. This means that our farmers pay a tax each year of from five cents to thirty cents on each dollar's worth of crop value, a tax that would not be tolerated if it were levied by any political unit, national, state or county or for any purpose be it good roads, better schools or what not.

Yet this tax is levied so insidiously that we in the experiment station never hear about it and never know anything about it except by direct personal observation, save when insects destroy 75 per cent, 95 per cent or 100 per cent of the crop which happens time and time again sometimes to isolated farmers, sometimes to practically all of the farmers growing any given crop. I have frequently had tobacco farmers tell me that the flea beetle did no damage, while at the same time we were standing in the midst of tobacco beds covering three times the area that he would have had to have under cloth if it had not been for the flea beetle.

What of the labor of preparing the soil? What of the fertilizer used? What of the extra yards of tobacco cloth that he was required to purchase? What of the fact that he was raising here a hoard of flea beetles that would follow the plants when they were transplanted to the fields and seriously check their growth when they could least afford to have their growth checked? What of the fact that these insects continued to eat holes in the leaves throughout the growing season so that when the crop was placed on the market he was forced to sell at a lower price than he would otherwise have had to sell? What of the fact that careful experiments show that a flea beetle will eat more than fifty times its own weight in green tobacco every twenty four hours? Translate that into hay for an average cow or horse and think what it would mean if you had to feed them from two to three tons every day. I happen to be interested in a group of insects called leaf hoppers and in their efforts on pasture lands. Does it mean anything that we find as high as one hundred of these tiny insects per square foot? Our mountain farmer might answer no because the chances are that he has never seen a leaf hopper but is this the correct answer? Careful experiments show that these insects actually get more from our pastures than the animals that are being pastured on them.

With such enormous losses due to insects it might seem that entomologists were not keeping pace with the insects but I do not believe that this is true. A brief summary of some of the more important results of economic entomology might not be amiss. When we stop to consider the tons of arsenical poisons used in this country and reflect that this whole industry was initiated by the work of entomologists we get a glimpse of the importance of this phase of entomology.

In 1888 the fluted scale, which had been introduced into California from Australia, had practically ruined the citrus industry. However, the Department of Agriculture sent a representative to Australia where he found that the fluted scale was kept in check by a lady beetle. This lady beetle was introduced into California and in nine months time it had so checked the ravages of the fluted scale that the scale ceased to be a menace and the citrus industry of California was saved.

As you open your packages of predigested breakfast food, I wonder how many of you have noticed that they are carefully wrapped in oiled paper and I wonder how many people have tried to find the real reason for this. It is all done to control the grain weevils and was worked out by an entomologist who has by this simple means saved a great and growing industry.

These are but a few of the many illustrations that I might have drawn from the great field of applied entomology but they will perhaps serve to illustrate its many phases.

INSECT FRIENDS.

Entomologists lay so much stress upon the damage caused by insects that it is small wonder that the public is inclined to look upon insects as pests and nothing else. It was that eminent British Entomologist, Sir John Lubbock, I believe, who brought the opposite point of view to our attention forcibly by reminding us that he could make the world a place unfit for human habitation in less than a year's time if he had the power to remove certain insects from the world. Which is simply another way of saying that while we suffer much from the attacks of injurious insects we owe much to insects which are our friends and help to keep injurious insects in control.

Entomologists are having these matters forced upon their attention but apparently the general public misses the significance of the outbreaks of certain species of insects. The army worm is a case in point. Normally this insect is present every year but not in sufficient numbers to cause any appreciable loss to the farmer. Occasionally, however, the army worm becomes locally or generally abundant and causes wide spread destruction and alarm. Even a better illustration is offered by the soy bean worm. A year or two ago this insect threatened the destruction of the soy bean crop of this and adjoining states causing hundreds of thousands of dollar's worth of damage. Yet this insect is not even mentioned in standard textbooks of entomology and had never been a serious pest before. Why these sudden outbreaks of insect pests? The reply is that these destructive outbreaks represent what happens when the control exercised by their enemies is for any reason released. In other words it represents the condition that would prevail but for our insect friends.

"The following analysis of a typical outbreak of the army worm will show what usually happens. As is usual during such outbreaks, large numbers of Tachina flies were to be found in the fields laying eggs on the worms. With the intention of making a more careful study of these parasites 491 larvae were brought back and placed in cages. The following data gleaned from the records of these cages are presented as being of some interest. Of the 491 larvae, 442 were infested with the eggs of the dipterous parasite, leaving only 49 larvae,

or 10 per cent of the whole number, uninfested, yet 61 larvae were able to pupate. From these 61 pupae, however, only 7 adult moths emerged, showing a total mortality among the Army Worm from larva to adult of 98.6 per cent. And since 90 per cent of the larvae were infested with the eggs of this parasite, it would seem to indicate that, in this case at least, the parasitic fly was decidedly the most important factor in causing the high mortality of the Army Worm. In a few cases it was found that where only a single parasitic egg was attached to a larva, that the host was able to complete its transformations.

"The greatest number of parasitic eggs observed on a single larva was 12, with an average of 3 for the entire number (442) infested. The 442 infested larvae yielded 709 parasitic puparia, or an average of nearly two for each infested larva. The 709 puparia yielded 556 adult parasites. The greatest number of adult flies from a single Army Worm was four. These figures show that the mortality of the parasitic fly from egg to puparium was 52 per cent, and from puparium to adult 22 per cent, making a total mortality from egg to adult of 73 per cent.

"This shows that the tendency would be for the fly to continually gain in relative numbers, owing to the lighter mortality, and easily accounts for the complete subjugation of the Army Worm in normal years by this one natural enemy. No other parasites were found in the course of these experiments."

Since we are so dependent upon these insect friends perhaps it would not be amiss to inquire a little more closely into their life economy. For convenience we may divide the friends of man into two groups, predacious insects and parasitic insects but this is merely a matter of convenience and the line separating the two is by no means a sharp one. For example we might inquire whether the larvae of the solitary wasps mentioned in another connection were parasitic or predacious and while in general their behavior is that of a predacious insect there is little doubt that this is simply a further development of a strictly parasitic habit. Likewise the line separating the predacious insects from the plant feeding forms is not great. Some species seem to feed predaciously if insect hosts are abundant, but if not available they turn their attention to plants. Hence we feel safe in saying that the evolution of these habits have been from plant feeding to predacious insects and thence to parasitic insects.

Predacious insects are many and they have varied habits. Some are active and search far and wide for their prey like the ground bee-

tles and tiger beetles. Others are quiescent and construct traps for their prey like the ant lions. These curious fellows usually called doodle bugs construct funnel like traps in loose sandy soil and then take up their position at the neck of the funnel and wait for a luckless ant to tumble in. The ant thus starts a miniature land slide which the ant lion aids by throwing loose sand above the ant. Some are predacious only in the larval stage like the aphis lion or the aphis maggot, while others are predacious both in larval and adult condition like the lady beetles. The amount of food that these predacious insects will consume is often beyond belief.

"In order to determine something of the capacity of these insects for devouring plant lice and hence their degree of economic importance, I tried feeding the larvae of *Syrphus americanus* on cabbage aphids (*Aphis brassicae* Linn.) The aphids were touched to the mouth of a larva which had not been kept from food. A four-day-old larva devoured the first aphid in 4.5 minutes, a second, third, fourth and fifth, smaller than the first, in 2, 1, 1, and 0.5 minutes, respectively. The sixth, a larger one, was retained for 3.25 minutes. These were very thoroughly eaten, all the viscera and body fluids being picked and sucked out. After this the lice tendered were not eaten so closely, but killed, a seventh in 2 minutes, an eight in 1.75 minutes, and a ninth in 1.5 minutes." An average of less than 2 minutes for each plant louse or 240 per eight hour union day.

"It is, of course, not probable that any larva would ever normally devour aphids so rapidly. Yet when plenty are at hand the number eaten by a larva during its life of eight days to two weeks or more must be very considerable. It should be kept in mind also that it is not the actual individuals eaten, alone, that determine the amount of benefit from these insects; but the fact that in this way the production of enormous number of aphids is prevented. If, as Reaumour has calculated, and others have substantiated, one aphid may be the progenitor of over 5,000,000,000 individuals during her existence of a month or six weeks, we can see at once the important benefit that must arise from the destruction of one or two of these aphids early in the establishment of the colony. It is a fact that the eggs of Syrphidae are often deposited on the host-plant very early or even in anticipation of the arrival of the aphids." (C. L. Metcalf.)

On the other hand the small amount of food on which these insects seem to be able to survive is almost beyond belief. I shall never forget a deserted wagon road below Carolina Beech where both tracks

were crowded with the funnels of the aphis lion. These funnels averaged more than four to the foot in an open space about 150 feet long between a woods and a swamp. The chances of an ant traveling that road were certainly slim, but the chances of an ant lion getting very many full meals must have been correspondingly slim. Yet each one of these little fellows had moved nearly a cubic inch of earth in constructing his funnel.

As important as these predacious insects are, they are by no means as important as the parasitic insects. Allusion has been made to the Tachina fly and the army worm. In addition to these parasitic flies there is a large group of parasitic wasps which are among the most important of the parasitic insects. Many of these forms are so small that very little is known about them. And I think I would be justified in saying that they are perhaps the least known of all of the insects. Yet we are gradually accumulating knowledge of these forms and some of the more important points are perhaps worth reporting here. We have among the parasitic wasps many parasites of the egg, larval and pupal stages of insects, but cases of adult parasites are not so common. Sometimes the egg of the parasite is laid in one stage but does not emerge as a perfect insect until a later stage. Usually the parasitic stage is confined to the larva which feeds upon its host while living within the appropriate stage of the host, but sometimes the parasite really lives externally as is the case with certain parasites of the gloomy scale which we have under investigation. Here the adult parasite lays her egg or eggs under the scale covering of the host. The larval parasite attaches itself to the host and sucks it dry just as a predacious aphis maggot devours a plant louse. When it has completely destroyed the scale it changes to a pupa and thence to an adult. The adult cuts a neat circular hole through the scale covering and makes its escape. One of the most interesting points about this parasite is the apparent ability of the female to tell the scale insects that have been parasitized. Although I have watched upwards of 150 of these parasites under the high power binocular I have yet to find a case where one has made the mistake of ovipositing upon a scale insect that is parasitized. It is exceedingly interesting to watch the business-like way that these little fellows have as they pass from scale to scale tapping each one with their antennae until they find a suitable host, then slipping the delicate ovipositor under the scale covering depositing one or two or three eggs and passing on to the next victim.

Among the many interesting things about these parasites not the

least interesting is the small size of many of the forms. This is especially true of some of the egg parasites which are among the smallest known insects. Imagine an insect small enough to pass all of its stages in an insect egg not much larger than the period in ordinary newspaper print and you will have a proper conception of their size. Then when you remember that each adult is furnished with a pair of eyes and a pair of antennae, three pairs of legs and two pairs of wings, with mouth parts and a digestive system, with a nervous system and sense organs and is endowed with instincts enough to feed on the nectar of flowers and to mate and to lay eggs in the proper host at the proper time; and all this in an insect not over ¼ mm. long or so small that one hundred of them placed end to end just equal an inch; with these facts all before you you will have a proper conception of the marvelous ability of nature.

I cannot pass the subject of parasitism without mentioning two special phases of insect parasitism, polyembryony and hyperparasitism. Polyembryony is that condition in which one egg gives rise to more than one adult individual. It is known to occur in many groups of the animal kingdom, for example, the identical twins of man and other mammals, the quadruplets of the armadillo and others. But this condition reaches its greatest development among insects where Patterson reports not less than 395 individuals from a single parasitic egg.

Hyperparasitism is even more wonderful than this for here we have the case of one parasite preying upon another. We have not only the primary parasite which preys upon the host but a secondary parasite preying upon the primary parasite and a tertiary parasite upon the secondary parasite and apparently in rare cases a quarternary parasite preying upon the tertiary. Can anything more involved be imagined? And can man ever hope to unravel the intricacies of the relations that must exist in such elaborate cases of hyperparasitism?

ECOLOGICAL RELATIONS.

The realm of ecology is as broad as the sum total of all of the factors that touch an insect during its life. It is therefore not surprising that we know so little about the ecological relations of insects. The temperature relations are perhaps the only ones that have been investigated with any degree of thoroughness and here our firm ground consists of a series of critical high and low temperatures for a few economic

forms. These critical temperatures are of great economic importance in the control of insects of stored products and hundreds of thousands of dollars worth of furs are now held at low temperatures during the summer months thus avoiding attacks of moths. While, at the other end of the temperature scale, we find many of our largest flour mills provided with special heating apparatus so that the temperature of the mill may be raised beyond the critical point for mill insects. When it is remembered that temperature is intimately related to humidity and other factors it is perceived that the problem is an exceedingly complex one and one that will have to await better facilities for controlling these factors than any as yet available. Perhaps the most interesting single bit of information as yet gleaned from the many important ones relative to the temperature factor is the knowledge that certain species of plant lice will withstand a much lower temperature than their parasites. Hence they are able to survive and continue to breed in cool weather whereas the development of the parasites is checked, thus the plant lice gains the upperhand of their parasites and do widespread damage to crops during cool weather, but if the weather is warm the parasites gain the upper hand and keep the plant lice in check.

Humidity is perhaps next to temperature, the most important single factor in the ecological relations of insects. Here again we have practically an unexplored field and outside of the knowledge that many insects require a relatively high humidity for their best development, our knowledge is rather limited. The fact that air passed through certain strengths of various salt solutions and solutions of certain acids can be given almost any percentage of humidity required is of great service to the entomologist and opens up a fertile but practically untouched field.

In addition to the above problems of the ecological factors, which may be called laboratory ecology, there is another realm to which I desired to call your attention namely, field ecology. In field ecology we are not concerned with the individual factors but with the environment as a whole. In other words we take our selected area as we find it in nature and try to analyze it by determining the dominant species and then determine the reasons for their dominance. The whole of economic entomology may be said to belong to the field ecology of insects but field ecology of insects is broader than economic entomology for it is concerned not only with economic forms but with others as well.

For the past few years I have been giving some attention to a problem in field ecology that is very interesting to me and perhaps a statement of this problem will do more than anything else that I might say to make the whole matter clear. We have along our ocean front, our sounds, bays and rivers a narrow strip of land that is flooded twice each day by the rising tide. This strip of land may be known as the tidal zone. The part of the tidal zone lying along the ocean front where it is affected also by the direct action of the waves may be known as the strand. While that portion of the tidal zone along the sounds, rivers and bays where it is not much subjected to wave action may be known as tidal belt. While these two areas may be generically related yet they are very distinct. The strand is usually devoid of vegetation and is frequented by a group of animals that we will call beach combers. All of them are scavengers and they feed upon whatever the ocean may cast up before them. Their existence would seem to be a precarious one but when we note the abundance of beach fleas, sand scabs, ghost crabs and beach tiger beetles we are inclined to believe that nature must be very lavish with them after all.

The tidal belt is far more interesting to us, however, chiefly because it usually supports a luxuriant growth of sedges and grasses which in turn support a wealth of leaf hoppers and plant hoppers which are my special interest in all of the groups of insects. The ecological relations of some of these insects are most interesting. Here we have strictly terrestrial air-breathing arthropods living in an environment that is strictly aquatic for longer or shorter periods twice each day. Here we have strictly terrestrial forms living in close proximity to strictly aquatic forms like the sea snails and fiddler crabs. Naturally we wonder why these insects have adopted this habitat. Perhaps we can explain it by stating that these insects attached themselves to their host plant when it was a xerophyte and simply followed it into its half hydrophytic environment. This may be historically correct, but whatever is the past history of this peculiar relation we know that it is not simply a strict host relation at the present time but it seems rather a matter of fixity of environmental factors. This is borne out by the fact that one of the most abundant species of plant hoppers in the tidal belt region lives on no less than three species of grasses and one sedge. Another species was described originally from Long Island where it was secured from a species of the genus Spartina but on our coast where Spartina is replaced by the sea oats (Uniola) the same species of the plant hopper occurs on the Uniola and occupies

the same situations. So much we know but there remains a vast deal more to be found out. Are these species limited in their zones by the amount of submergence that they can withstand? What are the physiological characters that make it possible for these species to survive such an environment whereas their generic relatives are confined to xerophytic habitats? These and many other questions we might ask but only time and an unlimited amount of field work can give the answer.

There is another ecological relation that it seems to me would be worth pausing to consider and that is the relation of insects to their hosts. The relation of insects to their animal hosts I have discussed in another connection under parasitism so that there is left for our consideration at this point the relation between insects and their plant hosts. This is a broad subject in itself and one deserving of more consideration than I am able to give it here.

Some insects are so limited in the selection of their hosts that it is safe to identify the insect from the host on which you find it; while other insects apparently will eat anything that is green. We have in some cases whole families of insects limited to a narrow group of plants in their host relations, for example the Coleopterous family Bruchidae confines its attacks to the seeds of the Leguminosae. On the other hand we have species that are structurally closely related feeding on widely diverse plants. In fact these relations are so marked that they have been used to correct our phylogenetic notions. Thus the botanist may use insect species in determining the relationships of his plant forms and the entomologist frequently corrects his taxonomic concepts on a purely botanical basis. Naturally such relations cannot fail to impress the serious student and leave him with a vague feeling of dissatisfaction at his failure to answer them. Thus I have puzzled my mind for many hours in the hope that I might be able to answer the question, why does the gloomy scale occur on soft maples in destructive numbers yet be practically absent from hard maples? Is it simply a difference in the thickness of the bark in the two groups of maples, or is it a difference in the chemical composition of the sap? Whatever the answer, the selection is remarkably clear cut because we frequently see rows of hard maples with a few soft maples interspersed in which the hard maples are free from scale and thrifty whereas the soft maples are dead or dying.

There is another series of ecological relations that is deserving of more than passing attention. I have already referred to that com-

plex chain reflex which causes the adult female insect to deposit her eggs so that the newly hatched young will find an abundance of food close at hand for its sustenance. These relations are easy to understand in those insects where the young and the adults feed upon the same host but they become increasingly difficult to understand as we pass to those adults which either do not feed or feed upon an entirely different substance. For example the adults of the order Lepidoptera, the butterflies and moths, feed on the nectar of plants for the most part yet their larvae feed upon roots, stems, leaves or seeds of plants or on animal products. The eggs must be laid in close proximity to such food or the larvae would perish and the species would vanish from the earth. What is the mechanics that brings this very desirable conclusion? We may answer that this series has become hereditarily instinctive but when we do so we are merely clothing our ignorance in a mass of verbiage.

The climax in this series of complex reflexes is reached among the solitary wasps to which I have alluded in another connection. This complex may be pictured briefly and in a somewhat generalized way as follows. The female wasp digs a burrow in the soil. She goes away and searches until she finds the proper prey, be it cicada, horsefly, caterpillar or spider. She pounces upon it and stings it in the thoracic ganglia so that the prey will be paralyzed but not killed, for if the prey were killed it would decay before the egg hatched and the young larva would starve to death. She drags or carries the prey back to the burrow, often a considerable distance, and by means of some sense that is beyond human understanding she locates the burrow and deposits her prey; lays her egg; closes the burrow and, wonder of wonders, has the time and the patience to conceal the entrance of the burrow by making it look like the surrounding territory. If in hard ground she seeks out a small pebble and pounds the loose dirt down until it blends in with the surrounding territory, or if in a tidal flat with a crust of salt she finds a bit of crust to cover the entrance. Such in brief is the story, but who has the insight to unravel the maze of ecological factors that are woven into such a complex?

Another series of ecological adaptations that is so common that it causes no comment is the relation between pollination and insects. Here we are confronted with a case of parallel development that if it were not so common or if it existed only in the South Sea Islands would be one of the wonders of the age, but because we see it everywhere about us, because it is the rule rather than the exception, it arouses

no more comment than the rising of the sun. Yet the elaborate floral devices, the presence of artfully concealed nectaries on the one hand and the presence of long tongues and pollen baskets among the insects show an evolution that must have been carried on for untold ages. And how dependent one group is on the other and any failure of the one group must necessarily mean the extinction of the other. I wonder how many such cases of sad wrecks we might find if we could reconstruct the past geological ages.

The highest form of interdependence is found perhaps in the case of the Yucca and the Yucca moth.

"The flowers of the species of Yucca are absolutely incapable of self-or-wind-pollination, and the stigma is so situated that no ordinary insect visitor can reach it in a casual search for food. In some localities, it was observed that the common Yucca never produced seed and that wherever seed was produced, almost every pod was infested by a little caterpillar that destroyed a greater or less percentage of the seeds. The parent of this caterpillar is a small white moth, the Yucca moth, in which the mouth-parts are curiously modified and utterly unlike those of any other moth species that we know. At the sides of the ordinary tongue there are developed a pair of flexible processes set with little pegs and spines, and capable of being coiled like the tongue itself. When the female, which alone has these processes, is ready to lay an egg she enters a Yucca blossom, gathers a little mass of pollen, rolls it into a ball, carries it by means of the processes to the pistil, and rams it down so as to bring it into direct contact with the receptive surface. Not until this has been completed does she turn and then into the ovary or embryo seed pod, she forces an egg by means of a slender, sharp-pointed ovipositor. She is now ready to repeat the process on another flower and she does repeat it until her stock of eggs is exhausted. Here we have a deliberate pollination preceding oviposition, as if the insect knew that it would be useless to lay an egg until the possibility of development in the seed pod was assured.

"This peculiarity, though confined so far as we know to the genus Pronuba, is not confined to one species only. There are a number of Yuccas in the country, including the giant or tree Yuccas of the southwest, and for every species of Yucca there is a species of Pronuba. Surely a most wonderful adaptation of insect and plant, neither of which can exist without the other.

"And yet, while the adaptation is not so specific, nor the evidence of design so apparent, the dependence of red clover upon long-tongued

bees is not less absolute. Australia has no native bumble-bee, and red clover was unknown there until the colonists began to cultivate it. There was no difficulty in making crops of forage; but it would not seed. Importing seed annually was expensive, and, naturally, the Australians were anxious to raise their own. This led to a study of the reasons for the failure, in the course of which the dependence of the plant upon bumble-bees was established. The remedy was obvious, and now European bumble-bees disport themselves among the Australian red clover, seed is plentiful, and interference with bumble-bees is a crime—as it should be rated everywhere.

"There are many others among the Hymenoptera that are useful in the work of pollination because of their habit of feeding among the flowers, even if not on them; but all this is based on the same visits which the flower encourages and of which it takes advantage; but no account of this sort of relationship could be considered even passably complete without some reference to the complicated relationship existing between the Smyrna fig and the minute little Blastophaga, a species whose life relations have been beautifully worked out.

"The Smyrna fig of commerce depends for its edible quality upon the ripened seeds that it contains. The fig is not really a true fruit as that term is generally defined, but is a thick fleshy envelope within which the flowers are contained. In the Smyrna fig these flowers are all female and no pollen is produced anywhere on the tree. Left to themselves, such trees could never produce ripe fruit, and that was the condition of the Smyrna fig orchards in California, prior to 1900. In the Mediterrenean countries, whence our commercial supply is derived, there are found beside the cultivated also several varieties of wild or caprifigs, which produce three crops of fruit during the season. These fruits contain male flowers, producing an abundance of pollen; but this pollen is never naturally discharged from the envelope containing the florets.

"Yet it was recognized by the fig-growers in the Orient that to obtain fruit of the commercial edible varieties, it was necessary to bring to them when in bloom, branches containing fruit of the caprifig, which were usually hung up in the tree which it was intended to fructify. This work of pollination is accomplished by the Blastophaga already referred to, although, far from benefiting itself in the process, the insect dies without even being able to continue its kind.

"In the caprifigs the female flowers are replaced by little gall-like swellings in which the larvae of the Blastophaga develop. One gene

ration of figs, the so-called 'mammae,' remain on the trees during the winter and by the time they are ready to drop, there is already on the trees a new or spring crop of fruit, known as the 'profichi.' By the time that this crop is in proper condition, the insects that have hibernated in the 'mammae,' are fully developed, the wingless and almost blind male Blastophaga has fertilized the female before she is even out of her cell, and the latter, leaving the dried-up fig by the small anterior opening, makes its way into the new figs, to provide for a new generation. In the 'profichi' this generation matures at the time the commercial Smyrna fig is in proper condition and the females, emerging pollen covered from the 'profichi,' enter the small opening of this true female flower receptacle if they find themselves in a tree bearing them. But in this Smyrna covering all the female florets are fully developed, and the gall-like swellings that replace them in the caprifigs are absent. The insect therefore moves about over the entire interior surface of the pouch, seeking a place to oviposit, and in the process distributes its load of pollen everywhere. It eventually dies without reproducing, and usually without even being able to make its way out again. But though the insect has lost its life, the tree has gained; and the seed pouch that we know as the fig, comes to maturity and ripens seed.

"At the same time that the Smyrna fig which produces the edible commercial fruit is in bloom, there is also another crop developing on the caprifigs, and these are known as 'mammoni.' The Blastophaga issuing from the 'profichi' on the same tree, naturally enter these fruits which are of the same character as the preceding crops, and are able to continue their kind, coming to maturity when the third crop is ready for their reception. This third crop represents the 'mammae' or over-wintering form, from which the 'profichi' of the following season are again entered by the Blastophaga.

"Here we have an extremely complicated relationship which, reduced to its simplest terms, means that in order to produce the commercial Smyrna fig there must be suitable caprifigs producing 'profichi' infested by Blastophaga, at a period corresponding to the development of the female flower capsule. And as the insects are very small and very frail, the caprifigs must be either well distributed among the Smyrna trees, or the infested 'profichi' must be gathered and distributed among the trees to be pollenized.

"This account makes interesting reading and shows how, after many trials and much painstaking investigation, the Blastophaga and the necessary caprifigs were finally introduced into the fig-growing

districts of California, and how a new industry, absolutely depending for its continuance upon a minute hymenopterous insect, was finally established upon a firm and scientific basis.

"How many cases of this kind exist among plants having no present economic value it would be difficult to estimate, and how so complicated a relationship ever became established is not yet explainable even by a theory." (Smith).

Fearing that I may weary you I am nevertheless impelled to point out another ecological relation that borders upon the marvelous. I refer to the relation between gall insects and their galls. We have here another case of parallelism in evolution. The galls range from simple folds of the leaf or simple enlargements of the stem to most elaborate and wonderful structures and the insects themselves are scattered in many orders. The most wonderful phase of the whole subject of galls and gall makers is the fact that the galls are absolutely specific. It is much easier to determine the gall maker by the gall that it makes than it is by the insect itself. Just what are the factors that cause any given cynipid gall, for example, to have the same form regardless of what species of oak it is found on? Just what is the stimulus that causes some galls to develop their form completely before the egg hatches? In addition to these perplexing questions we have the whole problem overlaid with the problem of parthenogenesis and alternation of hosts we can appreciate that we have here a problem that demands the best that any biologist can give. And the biologist who tackles these problems may rest assured that the field is broad enough to demand the best efforts that he can put forth.

CONCLUSION

Having considered briefly the past accomplishments in entomology it may be worth our while to turn our attention in another direction and ask ourselves what of the future. I do this because we are somewhat prone to think that all that is good, all that is worth while lies behind us. Having lived through an age that has seen the development of the automobile, the telephone, the aeroplane, wireless and half a dozen other world astounding inventions we are inclined to think that all the great inventions and discoveries have been made and that there is little left to do. Which reminds me of a personal experience that will perhaps make the matter clearer than anything else that I might say. When I was a senior in high school I was told that for good and suf-

ficient political reasons I could have an appointment to West Point if I could pass the examinations. I was persuaded not to do this by the Superintendent because, said he, "All the great wars have been fought, and you are not the type of young man that would care to hang around an army barracks all your days." Needless to say I agree that I am hardly that type of man but I also imagine that very few of the graduates of West Point in the class of 1907 spent many days hanging around army barracks from April 1917 to November 1919. I remember telling this story to my old teacher of Zoology and he said that when he told his Professor of Natural Sciences that he expected to go into Zoology his teacher tried to discourage him. "For," said he, "now that Darwin has announced his theory of Natural Selection there is nothing left for the zoologist to do."

I cite these two instances because they illustrate so well an all too prevalent opinion in all fields, a feeling that is far too prevalent in a new field like entomology where the pioneers have been over the ground and harvested the first rich harvest not realizing that these same pioneers have left many corners untouched and have left abundant harvests yet to be garnered. That such a feeling should be still prevalent in applied entomology in the face of such enormous losses as have been pointed out above or in the face of the fact that tons of honey go to waste each year and bees are needed to gather it, is indeed hard to realize. That such a feeling should be prevalent in pure entomology when we realize how Morgan has advanced the science of genetics by breeding fruit flies, or when we consider what there is yet to learn about the anatomy, the physiology or the ecology of even our most common species is hard to understand. Except perhaps there is the notion that the pioneers had an easy time when we think that, no matter which way they turned, they were almost certain to stumble into unexplored fields. While if we want to be sure that our work is not simply a repetition of something that someone else has done much better we must wade through a mass of literature often mountain high to discover nothing at the bottom. Forgetting for the time being that they had no great laboratories fitted with the finest of microscopes, microtomes, ovens, cameras and utensils of all kinds, that they had no libraries, no collections and very little appreciation. While we have all of these things. Forgetting that most of the pioneers had to steal their time for research from their families or from their sleep. While all that it is necessary for us to do is to steal the time from our classes or other official duties.

With all of these things in mind, I cannot help but feel that in spite of the past brilliant record of entomology there are better things just ahead of us. That undiscovered laws of life are awaiting the searching eye of the worker in entomology. That as yet unheard of methods of control are about to be discovered, making it possible for us to reduce the tax we pay to insects to a negligible minimum, thus making possible an expansion in food production as yet undreamed. Feeling this way, I cannot help wondering if the world will be ready for these discoveries when they are made or will they lie buried as Mendel's work remained forgotten for nearly half a century? Will we accept them at their true value or will we cast them aside as worthless? The Hindoos have a legend that illustrates our present tendencies very well indeed. A young man had an iron bracelet placed on his wrist one morning and was told that on a certain beach there was a stone that would turn the bracelet into gold. So he hastened out in the morning light and commenced to pick up the pebbles one by one and touched them rapidly to the bracelet and observed the results with a critical eye. Thus he labored all through the long morning of his youth but as the sun climbed higher and higher, as the day got hotter and hotter, his speed slackened and he commenced to ask himself if it was really worth while. Wasn't the whole thing a hoax any way? Certainly no one but a fool would believe that you could turn an iron bracelet into gold. Thus he labored through the noon-time half persuaded to stop but as the day advanced and his shadow got longer to the east and as he realized that the day was fast slipping away, he commenced to work with renewed energy that gradually changed to frenzy as the shadows of evening began to creep up from the valleys. And then as he looked down in the half light he noticed that the bracelet had indeed turned to gold. But he also realized that in his haste and in his carelessness he did not know which was the magical stone.

RALEIGH, N. C.

THE GENUS RASPAILIA AND THE INDEPENDENT VARIABILITY OF DIAGNOSTIC FEATURES

By H. V. Wilson

The genus Raspailia (Nardo, 1833, 1847; O. Schmidt, 1862, p. 59) was classed by Ridley and Dendy, 1887, p. 188, in the Axinellidae but transferred by Topsent, 1894, to the Ectyoninae. In this Topsent has been generally followed, including Dendy, 1895 (p. 46), who here regards the genus as intermediate between the two groups. Dendy later (1905, p. 172) departs from this view and regards the resemblance of Raspailia to the Axinellidae as strong but superficial. Hentschel (1912, p. 413) brings out the skeletal resemblance between the Ectyonine genera centering round Raspailia and certain Axinellidae, and inclines to regard it as due to kinship and not to convergent evolution, thus maintaining the position of Dendy in 1895. Vosmaer, 1912, keeps Raspailia alongside of Axinella, Phakellia, Acanthella, and Phacanthina, thus indicating his belief in a relationship to these genera. George and Wilson, 1919, pp. 160–161, in describing *Axinella acanthifera* regard it as intermediate between typical Raspailias and Axinellas. In this species there are some acanthostyles and the dermal brushes include a few long slender styles, but the habitus is lamellate, and the skeletal framework of the same type as in *Axinella verrucosa* (Vosmaer, 1912).

In delimiting Raspailia more precisely, Vosmaer, 1912, p. 313, takes the Mediterranean *R. viminalis* (O. Schmidt, 1862, p. 59) as embodying the characteristics of the genus. The characters emphasized are: the axial skeleton is a funis (a reticular bundle composed of elementary fibres or funiculi) with wide meshes, component funiculi thin, spicules wholly or almost wholly imbedded in spongin; from this, slender and short extra-axial funiculi (radial fibres), composed of one, two, or three spicules cemented together by spongin, radiate to the surface, where each terminates in a single large style or subtylostyle, projecting far beyond the surface, surrounded at its base by a tuft of diverging small spicules, generally styles, sometimes oxea. Acanthostyles occur, dispersed in the parenchyma and echinating the funiculi. Skeletal megascleres, chiefly long, slender styles, occasionally tylo-

styles and strongyles, also generally oxea. Habitus cylindrical, long and slender, branching or not branching.

The long, slender, cylindrical habitus, with skeletal framework on the general axinellid plan, and the presence of acanthostyles have been regarded by many (Ridley, Ridley and Dendy, Dendy,) as the chief distinguishing characteristics of the genus. The acanthostyles may entirely disappear but the other characteristics remain, as in subgenus Syringella Ridley (1884, p. 460). Examples are: *Raspailia syringella* O. Schmidt (1868, p. 10) and the two species described by Ridley, loc. cit. In *R.*[*Syringella*]*falcifera* Topsent (1890, p. 12; 1892, p. 124) the habitus is fairly typical, and the dermal skeleton adheres to the *R. viminalis* type. In *R.* (*Syringella*) *rhaphidophora* Hentschel (1912, p. 371), the habitus is typical, save that the branches are generally compressed; instead of radial fibres, there are radial partitions (lamellae); dermal skeleton of the *R. viminalis* type; megascleres, styles, oxea, strongyles; microscleres present in shape of bundles of rhaphides. In *R.* (*Syringella*) *nuda* Hentschel (1911, p. 383) the habitus is typical; axial skeleton with radial fibres; dermal skeleton as in *R. viminalis*. All these forms make it plain that the general practice with respect to Syringella is correct and that such sponges are really members of the Raspailia group in which the acanthostyles have been lost, and should not be relegated on a technicality to the Axinellidae while Raspailia is referred to the Ectyonidae. Nevertheless Topsent (1904, p. 138) takes this position. Pick's position (1905, pp. 18–19) is different and is not opposed to the argumentation of this paper, for while assigning to the Syringella forms the dignity of a genus, he keeps the latter alongside of Raspailia.

A consideration of a number of the species usually assigned to Raspailia makes it plain that Vosmaer's generic concept cannot be applied in all of its details, especially in the matter of the dermal skeleton and the greatly reduced radial fibres. On the other hand the slender, elongated, cylindrical shape of body, sometimes branching, sometimes not, on which Ridley and Dendy (1887) laid chief emphasis, while common, is by no means constant. In fact, in this group of forms, as elsewhere, the characters have varied independently during the course of evolution, thus giving rise to several combinations. A generic concept of Raspailia, to be useful, must take into account the existence of these combinations, and cannot insist absolutely on the slender cylindrical habitus, dermal bunches of spicules such as occur in *R. viminalis*, monactinal character of the megascleres, or on the acantho-

styles. And yet this is what the recent definitions of the genus do, with the result that Dendy's definition (1905, p. 172) would exclude forms that are admissible on the definition of Vosmaer (loc. cit.) or of Hentschel (1911, p. 381), and *vice versa*. Of course the difficulty is well known. It is a difficulty offered everywhere by nature.

A considerable number of species, over thirty, have been referred to this genus. A good many of them are excluded by Pick in his essay on Raspailia (1905). He would delimit the genus somewhat more narrowly than is intended in this paper. Taking R. *viminalis* as a standard, some of the chief divergencies within the genus may be enumerated. It is to be regretted that in a number of the old species the data given do not permit a decision with regard to several of the features.

Habitus.

The long, slender, cylindrical habitus, "whip-like" in Ridley and Dendy's terminology, branching or not, is common. But it is departed from in a number of species. For example, while the habitus is branching and subcylindrical, the branches are comparatively short and stout in several of the Dictyocylindrus (Raspailia) species described in Bowerbank's British Sponges, in *R. ramosa* and *R. pumila* e. g. In *R. paradoxa* Hentschel (1911, p. 381), the habitus departs widely from the typical, the sponge consisting of several somewhat flattened lobe-like divisions, which arise together from a common base and expand above. Again in *R. irregularis* Hentschel (1914, p. 121) the habitus deviates markedly from the typical, the sponge being club-shaped.

Skeleton.

The axinellid type of skeletal framework consisting of an axial column and radiating fibres may be thought of as constant in Raspailia. Deviations from the precise form of skeletal framework found in *R. viminalis* are however common among the species that have been referred to this genus. Some of them may be enumerated as follows: In *R.* (*Syringella*) *clathrata* Ridley (1884, p. 461) the radial fibres are thick, not reduced as in *R. viminalis*. In *R.* (*Syringella*) *australiensis* Ridley (loc. cit. p. 460) also the radial fibres are thick and project at the surface, but the surface tufts are not said to be of the *R. viminalis* type. In *R.* (*Syringella*) *rhaphidophora* Hentschel (1912, p. 371), the radial fibres are represented by lamellae. In *R. bifurcata* Ridley (loc. cit. p. 459) a radial fibre and dermal tuft are together represented by a long style or a tuft of long styles which project at the surface (a more

reduced condition than in *R. viminalis*). In *R. hornelli* Dendy (1905, p. 172), the dermal tufts in which the radial fibres terminate include a few long styles, instead of one, surrounded by shorter ones; another deviation is made in the presence of connectives between the radial fibres. In *R. irregularis* Hentschel (1914, p. 121) the large dermal projecting spicules are in bunches and not singly as in *R. viminalis*.

In *R. flagelliformis* Ridley and Dendy (1887, p. 190), the radial fibres, apparently not especially slender, terminate in projecting tufts of small spicules; habitus is typical but if we lay stress on the dermal skeleton the species must be removed to Axinella. In *R. cacticutis* Carter (Dendy, 1895, p. 48), there are no surface tufts of spicules, and the species would best be assigned to some other genus, as Pick (loc. cit.) has done.

The *R. viminalis* type of dermal skeleton is known to occur in a number of species, and it may also occur in some of the older species for which the data are imperfectly given.

Spicules.

The skeletal spicules in the genus are smooth and in general styles, varying to tylostyles, but oxea and strongyles may occur intermingled with the styles (*R. viminalis* Schmidt, *R. bifurcata* Ridley, *R.* (*Syringella*) *rhaphidophora* Hentschel). A marked deviation is afforded by *R. vestigifera* Dendy (1895, p. 47; assigned by Pick, loc. cit., to the closely related genus, Echinodictyum), in which the skeletal spicules are oxea, except the small spicules of the dermal tufts which are inequiended and more or less stylote; in this species the radial fibres are stout, but the dermal tufts adhere in plan to the type of *R. viminalis*; acanthostyles are very rare and in this sense vestigial.

The acanthostyles may be almost (*R. vestigifera*) or quite absent, the species in which this loss has occurred being grouped together as a subgenus (Syringella). Microscleres in the form of bundles of rhaphides, may occur as in *R.* (*Syringella*) *rhaphidophora*; in general, absent.

The facts being so, it would seem advisable to recognize Raspailia as a comprehensive, heterogeneous genus, and to include in the diagnosis the chief lines of variation, about as follows:

Raspailia Nardo

Habitus often slender and cylindrical, branching or not; but the branches or unbranched stem may be comparatively short and stout, or the branches may even appear as flattened lobe-like divisions. The

skeleton is on the axinellid plan, including an axial dense aggregation of spiculo-fibres from which radial fibres pass outward. The radial fibres may be comparatively stout, sometimes expanded and forming lamellae, or may be reduced to one or a few spicules, or may even disappear as structures distinct from the dermal brushes in which they terminate. Connectives between the radial fibres generally absent, occurring only in a few species. The dermal brushes characteristically include one or a few long megascleres surrounded by numerous shorter ones, but the entire brush may be represented by one or a bunch of long megascleres, whereas in Axinella the radial fibres terminate "in tufts of diverging spicules slightly smaller than the bulk of the spicules" (Vosmaer). Skeletal spicules smooth and characteristically monactinal, but diactinal forms (to be looked on as variants of the type) are frequently intermingled, and in rare cases most of the spicules are diactinal. Acanthostyles characteristically occur, echinating the skeletal fibres and scattered, but in some species they are greatly reduced in number, in others absent (subgenus Syringella). Microscleres generally absent but may occur as bundles of rhaphides.

In considering a generic concept such as that just formulated one must remember that classification is no mere mechanical assorting, a putting of like with like. That much of it is easy and delightful, but the fact that the features used in the classification of a group are or may be independent variables, that is, may occur together or some may be absent or greatly modified, makes classification more dependent on argument than is generally recognized. Often, to be sure, no argument is conclusive, in the end there being several options about equally good. In such a case some consensus of opinion as to the best, most useful, practice is desirable. All this applies to the delimitation of such genera as Raspailia.

One other consideration must be kept in mind in considering such generic concepts, and that is that variation may have proceeded in such a way as to make it quite impossible, in the present state of our knowledge of diagnostic points, to recognize the relationship of a given species to the genus. If, for instance, the acanthostyles are lost, a typical habitus and dermal skeleton would still show the relationship, or even the peculiar dermal skeleton might be accepted, in the absence of acanthostyles and typical habitus, as a safe index. But the dermal bunches, as we have seen, may also vary from the type, and if habitus, peculiar dermal skeleton, and acanthostyles all go, nothing remains to show the relationship. I take it that such eventualities may have

actually happened, since, it would seem, we must recognize as a real i. e. natural, process the independent varying of characters. This consideration brings with it the conviction that classification in its details cannot be a completely satisfactory guide to relationship. Minor uncertainties will occur everywhere.

The only species of Raspailia recorded for our waters (North America and West Indies), are the following:

R. hamata O. Schmidt (1870, p. 62), West Indies. The diagnosis is very incomplete and Schmidt puts a query as to the genus. But the species, which is of typical habitus, is probably to be referred here. (*R. tenuis* Ridley and Dendy, 1887, p. 188, occurs off the Brazilian coast in shallow water to twenty fathoms).

R. acanthifera (George and Wilson), North Carolina coast (Fort Macon Beach). Somewhat reluctantly I conclude that this species originally referred to Axinella shoud be transferred to Raspailia, because of the presence of acanthostyles and the character of the dermal brushes, which consist of a bunch of ordinary styles together with one to a few long ones projecting far beyond the others. The species is to be regarded (cf. George and Wilson, 1919, p. 160), as a connecting link between Raspailia and Axinella.

When one speaks, as in this paper, of the independent variability of structures, it is not meant to imply that any part of a body is really an independent variable. It would rather seem from all that is known concerning racial differences, that where a race has varied from the ancestral type in one feature which is conspicuous from our present view-point, it has probably come to differ from the type in a great many other features, although these may become known to us only gradually as we become intimately familiar with the race in question. It is possible and convenient to refer, as I and others have pointed out, all this kind of variation in natural races to the gene theory, since in contemporary speculation a gene is a germinal unit which, like a molecule in a radical, may influence the organism (compound) in many different directions.

A good case of close correlation between specific characters in the matter of variability has been pointed out in recent years by Hentschel (1913 a, b), who has shown that in the silicious sponge Mycale (Esperella) a large number of characters ("character values" as Hentschel calls them, representing the concrete realizations of a schematic character, itself an abstraction drawn from a survey of the several

realizations) are co-dependent, all varying, or rather having varied in the same direction. They are, as Hentschel says, "functions of one another or of the same variable," the latter an environmental factor. We must of course suppose, since presumably we are dealing with germinal and not with somatogenic characters, that the environmental (external or internal) factor, as it increases in force, continues to modify the germ in the same detail of its constitution (same gene or gene complex) and in the same direction. This brings us well into the field of speculation, but without speculation no rational experimentation.

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AN INTERESTING MAXIMAL CASE*

By Archibald Henderson and H. G. Baity

Plate 3

In lists of problems dealing with maxima and minima may commonly be encountered the following:

To find the dimensions of the rectangle of maximum area that can be inscribed in an ellipse of semi-axes a and b.

Various methods may be employed for the solution of this problem; but these ordinarily suffice to veil the characteristic features of the solution, as viewed in the present paper. An enumeration of the methods usually employed will bring this into prominence. The interesting feature of the problem, under the method here stressed, is the introduction of an auxiliary curve which plays a dominant role in the solution.

Method I

If we represent a critical value by A and Δx by h, the customary conditions for a maximum are

$$f(A - h) - f(a) = \text{positive quantity}$$
$$f(A) - f(A + h) = \text{positive quantity}$$

If we represent the sides of the rectangle, inscribed in the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ by 2x and 2y, the area of the rectangle is given by

$$U = 4xy.$$

Since, from the equation of the ellipse, $y = \frac{b}{a}\sqrt{a^2 - x^2}$,

$$\therefore U = \frac{4b}{a}x\sqrt{a^2 - x^2} = \frac{4b}{a}\sqrt{a^2x^2 - x^4}.$$

Let

$$f(x) = (a^2x^2 - x^4)^{1/2} = x(a^2 - x^2)^{1/2}.$$

To find the critical value, set $f'(x) = 0$

$$\therefore \tfrac{1}{2}(a^2x^2 - x^4) - \tfrac{1}{2}(2a^2x - 4x^3) = 0.$$

Hence

$$2x(a^2 - 2x^2) = 0;$$

which gives $$x = 0, \pm\frac{a}{\sqrt{2}}.$$

* This investigation, which had been directed by Dr. Henderson, was presented by Mr. Baity before the Mathematics Club, University of North Carolina.

We exclude the value $x = 0$, since it obviously gives the minimum rectangle, of zero area. For the present, we may omit the value $x = -\frac{a}{\sqrt{2}}$ from consideration — primarily because a negative length would ordinarily be excluded in seeking a positive area. We shall revert to this case, however, in the latter part of the paper. Confining our attention to the value $+\frac{a}{\sqrt{2}}$, we have:

$$f(A) = \frac{a}{\sqrt{2}}\left(a^2 - \frac{a^2}{2}\right) = \frac{a^2}{2}$$

$$f(A-h) = \left(\frac{a}{\sqrt{2}} - h\right)\left(a^2 - \frac{a^2}{2} + a\sqrt{2}\,h - h^2\right)^{\frac{1}{2}}$$

$$= \left(\frac{a}{\sqrt{2}} - h\right)\left(\frac{a^2}{2} + ah\sqrt{2} - h^2\right)^{\frac{1}{2}} = \left(\frac{a}{\sqrt{2}} - h\right)\left\{\left(\frac{a}{\sqrt{2}} + h\right)^2 - 2h^2\right\}^{\frac{1}{2}}$$

$$= \frac{a}{\sqrt{2}} - h\left\{\frac{a}{\sqrt{2}} + h - \frac{h^2}{\frac{a}{\sqrt{2}} + h} + \text{-----}\right\}$$

$$= \frac{a^2}{2} - h^2 - \frac{\frac{a}{\sqrt{2}} - h}{\frac{a}{\sqrt{2}} + h}h^2 \text{-----}$$

$$\therefore f(A) - f(A-h) = +h^2 + \frac{\frac{a}{\sqrt{2}} - h}{\frac{a}{\sqrt{2}} + h}h^2$$

$$= h^2\left|1 + \frac{\frac{a}{\sqrt{2}} - h}{\frac{a}{\sqrt{2}} + h} \text{-----}\right|$$

This is a positive quantity, since as h approaches zero, h^2 remains positive, the first two terms are positive, and the remaining terms approach zero, since they all involve powers of h, and indeed h^2.

Proceeding in similar fashion, we derive

$$f(A) - f(A+h) = \frac{a^2}{2} - \left(\frac{a}{\sqrt{2}} + h\right)\left(a^2 - \frac{a^2}{2} - a\sqrt{2}\,h - h^2\right)^{\frac{1}{2}}$$

$$= \frac{a^2}{2} - \left(\frac{a}{\sqrt{2}} + h\right)\left\{\left(\frac{a}{\sqrt{2}} - h\right)^2 - 2h^2\right\}^{\frac{1}{2}}$$

$$= \frac{a^2}{2} - \left(\frac{a}{\sqrt{2}} + h\right)\left\{\frac{a}{\sqrt{2}} - h - \frac{h^2}{\frac{a}{\sqrt{2}} - h} + \text{-----}\right\}$$

$$= \frac{a^2}{2} - \frac{a^2}{2} + h^2 + \frac{\frac{a}{\sqrt{2}} + h}{\frac{a}{\sqrt{2}} - h}\ h^2 \text{------}$$

$$= h^2\left|1 + \frac{\frac{a}{\sqrt{2}} + h}{\frac{a}{\sqrt{2}} - h} \text{------}\right|$$

This is likewise a positive quantity, by similar reasoning to that given above. Hence $x = + \frac{a}{\sqrt{2}}$ is a critical value, which gives rise to a maximum. From the equation of the ellipse, the corresponding value of y is $+ \frac{b}{\sqrt{2}}$ Rejecting the negative value as giving rise to a negative area, we have for the value of the maximum area $4 \frac{a}{\sqrt{2}} \cdot \frac{b}{\sqrt{2}} = 2ab$.

METHOD II

Representing a critical value by A and Δx by h, the customary conditions for a maximum are

$$f'(A - h) = \text{positive quantity;}$$

$$f'(A + h) = \text{negative quantity.}$$

As before, let

$$f(x) = (a^2x^2 - x^4)^{\frac{1}{2}}$$

$$\therefore f'(x) = \frac{2a^2x - 4x^3}{2(a^2x^2 - x^4)^{\frac{1}{2}}} = \frac{a^2 - 2x^2}{\sqrt{a^2 - x^2}}$$

Since $A = + \frac{a}{\sqrt{2}}$ we have

$$f'\left(\frac{a}{\sqrt{2}}-h\right)=\frac{a^2-2\left(\frac{a^2}{2}-\frac{2a}{\sqrt{a}}h+h^2\right)}{\sqrt{a^2-\left(\frac{a^2}{2}-\frac{2a}{\sqrt{2}}h+h^2\right)}}$$

$$=\frac{\frac{4ah}{\sqrt{2}}-2h^2}{\sqrt{\frac{a^2}{2}+\frac{2a}{\sqrt{2}}h-h^2}}$$

$$=\frac{2h\,(a\sqrt{2}-h)}{\sqrt{\left(\frac{a}{\sqrt{2}}+h\right)^2-2h^2}}$$

which is a positive quantity.

Also

$$f'\left(\frac{a}{\sqrt{2}}+h\right)=\frac{a^2-\left(2\frac{a^2}{2}+\frac{2a}{\sqrt{2}}h+h^2\right)}{\sqrt{a^2-\left(\frac{a^2}{2}+\frac{2a}{\sqrt{2}}h+h^2\right)}}$$

$$=\frac{-\frac{4a}{\sqrt{2}}h-2h^2}{\sqrt{\frac{a^2}{2}-\frac{2a}{\sqrt{2}}h-h^2}}$$

$$=\frac{-2h\,(a\sqrt{2}+h)}{\sqrt{\left(\frac{a}{\sqrt{2}}-h\right)^2-2h^2}}$$

which is a negative quantity.

Hence $x=+\frac{a}{\sqrt{2}}$ is a critical value, which gives rise to a maximum. As before, we find for the value of the maximum area, 2ab.

METHOD III

We may deal with the function as an implicit function in the variables x and y, subject to the condition that the given point lie upon the required ellipse.

Thus

$$U \equiv F(x,y) = 4xy \quad . \quad . \quad . \quad (1)$$

subject to the condition

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - 1 = 0 \quad . \quad . \quad . \quad (2)$$

The critical values for maxima and minima are to be found by equating to zero the first derivative of U, and replacing $\frac{dy}{dx}$ by its specific value as derived from (2).

Thus

$$\frac{dU}{dx} = 4y + 4x\frac{dy}{dx} = 0 \text{ from (1)},$$

and

$$\frac{2x}{a^2} + \frac{2y}{b^2}\frac{dy}{dx} = 0, \text{ from (2)}$$

Hence

$$\frac{dy}{dx} = -\frac{b^2x}{a^2y}$$

which on substitution in the equation $\frac{dU}{dx} = 0$,

gives

$$4y + 4x\left(-\frac{b^2x}{a^2y}\right) = 0$$

and therefore

$$a^2y^2 = b^2x^2$$

Combining with (2), we have

$$2b^2x^2 = a^2b^2$$

giving

$$x = \pm\frac{a}{\sqrt{2}}, \text{ and therefore } y = \pm\frac{b}{\sqrt{2}}$$

The criterion for a maximum value is

$$\frac{d^2U}{dx^2} = \text{negative quantity.}$$

Now

$$\frac{d^2U}{dx^2} = 4\frac{dy}{dx} + 4x\frac{d^2y}{dx^2} + 4\frac{dy}{dx}$$

But

$$\frac{dy}{dx} = \frac{-b^2x}{a^2y}$$

and

$$\frac{d^2y}{bx^2} = -\frac{\left(a^2b^2y - a^2b^2x\frac{dy}{dx}\right)}{a^4y^2} = -\left(\frac{a^2b^2y^2 + b^2x^2}{a^4y^3}\right)$$

$$= \frac{-b^2(a^2b^2)}{a^4y^3} = \frac{-b^4}{a^2y^3}.$$

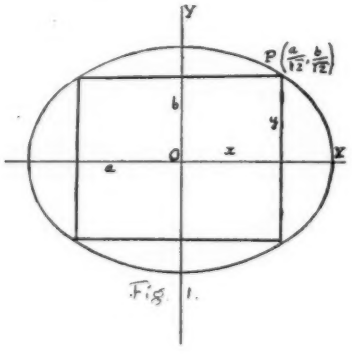
Hence

$$\frac{d^2U}{dx^2} = \frac{-8b^2x}{a^2y} - \frac{4b^4x}{a^2y^3},$$

which is negative certainly for the values

$$x = +\frac{a}{\sqrt{2}};\ y = +\frac{b}{\sqrt{2}}$$

Consideration of the other combinations of signs will be deferred until the last method is reached.



METHOD IV

We may deal with the problem by expressing U as an explicit function in either x or y. Thus, solving (2) for y, we have

$$y = +\frac{b}{a}\sqrt{a^2 - x^2},$$

and hence

$$U = 4xy = \frac{4bx}{a}\sqrt{a^2 - x^2}$$

since we reject here the consideration of a negative area, a being always greater than x.

Let

$$f(x) = x\sqrt{a^2 - x^2} = (a^2x^2 - x^4)^{1/2}$$

Then

$$f'(x) = \frac{x(a^2 - 2x^2)}{(a^2x^2 - x^4)^{1/2}} = \frac{a^2 - 2x^2}{(a^2 - x^2)^{1/2}}$$

and

$$f''(x) = \frac{(a^2 - x^2)^{1/2}\ (-4x) - (a^2 - 2x^2).\ \dfrac{-2x}{2(a^2 - x^2)^{1/2}}}{(a^2 - x^2)}$$

$$= \frac{x(2x^2 - 3a^2)}{(a^2 - x^2)^{\frac{3}{2}}}$$

Setting $f'(x) = 0$, and solving we obtain

$$x = \pm\frac{a}{\sqrt{2}}$$

Since we have assumed that $\sqrt{a^2 - x^2}$ is to have the positive sign, in order to reject the consideration of negative areas, we obtain, on substituting $x = +\frac{a}{\sqrt{2}}$ in $f''(x)$,

$$\frac{\frac{a}{\sqrt{2}}(a^2 - 3a)}{\sqrt{\frac{a^2}{2}}} = \frac{-2a^3}{\frac{a^2}{2}} = -4$$

which proves that $x = +\frac{a}{\sqrt{2}}$ gives a maximum value, as the condition for a maximum is that

$f''(A)$ = negative quantity.

The same conclusion would have been reached had we expressed U as an explicit function of y, and followed a similar course of reason-

ing. In that case we would have found that $y = +\frac{b}{\sqrt{2}}$. In either case, the final value of U would have been the same, namely 2ab.

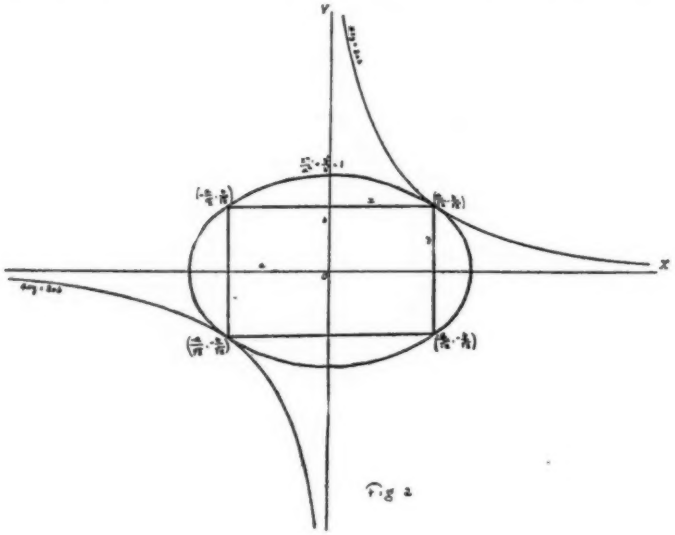


Fig 2

METHOD V

By employing the parametric representation for an ellipse, we readily obtain a very elegant solution of the problem. Any point on the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ may be represented by

$$x = a \cos \phi$$
$$y = b \sin \phi$$

when ϕ is the eccentric angle of the point on the ellipse, namely the angle between the x – axis and the line joining the origin to the point of intersection of the line $y = b \sin \phi$ with the circle $x^2 + y^2 = a^2$.

Substituting the parametric values of x and y into the equation $U = 4xy$, we have

$$U = 4a\cos\phi \cdot bs\sin\phi = 2ab\sin 2\phi \quad . \quad . \quad . \quad . \quad (1)$$

To find the critical value of ϕ for a maximum value of U, set the first derivative of U with respect to ϕ equal to zero:

$$\frac{dU}{d\phi} = 4ab\cos 2\phi = 0;$$

whence

$$2\phi = 90° \text{ or } 270°$$
$$\phi = 45° \text{ or } 135°$$

Accordingly

$$x = +\frac{a}{\sqrt{2}}, \quad y = +\frac{b}{\sqrt{2}}.$$

Now

$$\frac{d^2U}{d\phi^2} = -8ab\sin 2\phi,$$

giving a negative value for $\phi = 45°$, but a positive value for $\phi = 135°$. Hence $\phi = 45°$ is the critical value for a maximum. Hence the only admissible values for giving a maximum are

$$x = +\frac{a}{\sqrt{2}}$$

$$y = +\frac{b}{\sqrt{2}}$$

Substituting these values in (1), we have

$$U = 4xy = 2ab,$$

from which

$$xy = \frac{ab}{2} \quad . \quad . \quad . \quad (2)$$

The form in which this result presents itself, namely that of a rectangular hyperbole $xy = K$, excites interest at once, and prompts a further investigation. The introduction into the problem of an apparently extraneous curve, not invoked in the original statement, suggests that this locus must play a crucial role in connection with the ellipse in the solution of the problem.

The co-ordinates $+\frac{a}{\sqrt{2}}, \frac{+b}{\sqrt{2}}$ and $\frac{-a}{\sqrt{2}}, \frac{-b}{\sqrt{2}}$ of two of the

four corners of the maximum rectangle inscribed the ellipse satisfy the equation of the rectangular hyperbola $xy = \frac{ab}{2}$. Accordingly the ellipse and the rectangular hyperbola, having two points in common, must either intersect each other or be tangential at the given points.

The tangent to the ellipse at the point (x_1, y_1) has the form

$$\frac{x_1 x}{a^2} + \frac{y_1 y}{b^2} = 1;$$

and hence we have for the tangent to the ellipse at the point $\frac{+a}{\sqrt{2}}$, $\frac{+b}{\sqrt{2}}$

$$\frac{ax}{a^2\sqrt{2}} + \frac{by}{b^2\sqrt{2}} = 1$$

or

$$\frac{x}{a} + \frac{y}{b} = \sqrt{2} \quad \ldots . (3)$$

The tangent to the rectangular hyperbola at the point (x_1, y_1) has the form

$$y_1 x + x_1 y = ab;$$

and hence we have for the tangent to the rectangular hyperbola at the point $\frac{+a}{\sqrt{2}}, \frac{+b}{\sqrt{2}}$

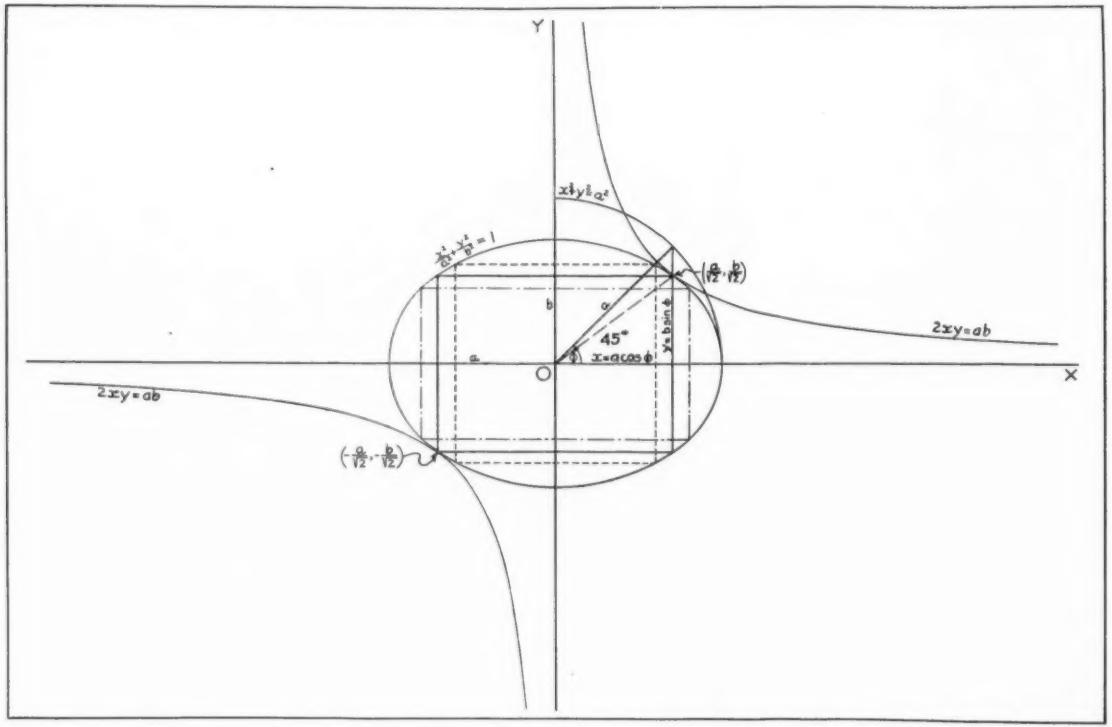
$$\frac{bx}{\sqrt{2}} + \frac{ay}{\sqrt{2}} = ab,$$

that is

$$\frac{x}{a} + \frac{y}{b} = \sqrt{2} \quad \ldots . (4)$$

As equations (3) and (4) are identical, it is clear that the ellipse and the rectangular hyperbola have a common tangent at the point $\frac{+a}{\sqrt{2}}, \frac{+b}{\sqrt{2}}$ It may be noted that, since the rectangular hyperbola consists of two branches lying respectively in the first and third quadrants, the ellipse and the rectangular hyperbola cannot intersect

PLATE 3



each other in either quadrant, since only one corner of the maximum rectangle inscribed in the ellipse lies in either quadrant.

Since the ellipse and the rectangular hyperbola have a pair of common tangents at two corners of the maximum rectangle, it is clear that the critical values may be arrived at by solving the two equations simultaneously. Thus substituting $y = \frac{ab}{2x}$ in the equation of the ellipse we have

$$b^2x^2 + \frac{a^4b^2}{4x^2} = a^2b^2,$$

or

$$4x^4 - 4a^2x^2 + a^4 = 0,$$

i. e.

$$(2x^2 - a^2)^2 = 0,$$

giving

$$x = + \frac{a}{\sqrt{2}};$$

and accordingly

$$y = \frac{ab}{2 + \frac{a}{\sqrt{2}}} = + \frac{b}{\sqrt{2}}.$$

At this point, or at an earlier point, in the investigation, the inquiry may be raised why both rectangular hyperbolas:

$$xy = + \frac{ab}{2}$$

and

$$xy = - \frac{ab}{2}$$

do not enter into the problem.

Although the question has virtually been answered in the course of the treatment in Method V, in the rejection of the solution $\phi = 135°$, it may be pointed out that while $x = \frac{-a}{\sqrt{2}}, y = \frac{-b}{\sqrt{2}}$ formally satisfy the equation

$$xy = \frac{ab}{2}$$

and give a rectangle of positive area, they derive from the rejected value $\varphi = 135°$. The two points

$$x = \frac{+a}{\sqrt{2}}, \; y = \frac{-b}{\sqrt{2}}$$

and

$$x = \frac{-a}{\sqrt{2}}, \; y = \frac{+b}{\sqrt{2}}$$

neither formally satisfy the fundamental function

$$xy = \frac{ab}{\sqrt{2}},$$

nor derive together from either $\varphi = 45°$ on $\varphi = 135°$.

The association of the ellipse and the rectangular hyperbola in this problem suggests the query whether the maximum rectangle inscribed in the ellipse is at the same time the maximum rectangle which may be inscribed in the rectangular hyperbola. This question must obviously be answered in the negative, since the rectangular hyperbola $xy = \frac{ab}{2}$ at once furnishes the result

$$U = 4xy = 2ab;$$

which shows the invariance of the rectangle area for the rectangular hyperbola, as indicated by the nomenclature.

The superiority of Method V over those which precede is conspicuous in two respects—the brevity and elegance of the treatment, and the immediate identification of the critical values which give rise to a maximum value.

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KEY TO THE BUTTERFLIES OF NORTH CAROLINA

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Butterflies may be distinguished from all other insects except the moths by the wings being covered with powdery scales which easily rub off, while from the moths they can be separated by having the antennae or feelers simple, and knobbed at tip, never hair-like, plume-like, comb-like, or even serrated. Furthermore all butterflies fly in the daytime, and most, but not all, moths at night.

The following key to the families of butterflies includes only six such, all the Nymphaline families or subfamilies, except the meadow browns, being lumped together, while our single species of the Erycinidae, or metal marks, is included in the Lycaenidae, which group it much resembles.

KEY TO THE FAMILIES OF BUTTERFLIES

1. Body stout, antennae hooked at tip (except in *Ancyloxipha*), species of medium or small size, mainly under two inches in spread of wings. Family VI. The Skippers (*Hesperidae*).
1. Body slender, antennae not hooked at tip....2.
2. Front legs normal, fitted for walking, outer edge of forewing always evenly rounded or straight....3.
2. Front legs brush-like, not fitted for walking....5.
3. Spread of wings 2½ to 5 inches, hind wings with tail-like projections which are never thread-like...Family I. The Swallowtail Butterflies (*Papilionidae*)
3. Spread usually two inches or less....4.
4. Ground color of wings white or yellow, hind wings never tailed. Family II. The Whites and Yellows (*Pieridae*).
4. Ground color of wings never white or yellow, hind wings often with thread-like tails..Family V. The Gossamer-winged Butterflies (*Lycaenidae*).
5. Size medium or large, colors usually bright, the prevailing shade being reddish brown....Family III. The Nymphs (*Nymphalidae*)
5. Size medium or rather small, ground color of wings some shade of dull brown, with eye-like spots almost always present on one or both sides of one or both pairs of wings. ....Family IV. The Meadow Browns (*Agapetidae*)

Family I. The Swallowtails

1. Ground color light, striped with black....2.
1. Ground color black, spotted with lighter....3.

2. Black and white, striped.....Zebra Swallowtail (*Papilio ajax*)
2. Black and yellow, striped.....Tiger Swallowtail (*P. glaucus turnus*)
3. Underside mainly yellow, spread about 5 inches.
Giant Swallowtail (*P. thoas*). East.
3. Underside mainly black.....4.
4. Body striped with yellow, hind wings crossed above by an uninterrupted yellow band.....Palamedes Swallowtail (*P. palamedes*). East.
4. Body not striped with yellow, hind wings not crossed by an uninterrupted yellow band.....5.
5. Underside of hind wings with two rows of yellow spots.....6.
5. Underside of hind wings with one row of yellow spots.....7.
6. Upper side of wings with usually two rows of light spots, inner row of yellow spots on under side of hind wings complete...Black Swallowtail (*P. polyxenes*).
6. Upper side of wings usually with only one row of light spots, fifth spot of inner row on under side of hind wings missing, and replaced by a comet like dash of scales.....Green-clouded Swallowtail (*P. troilus*).
7. Wings glossy above, yellow spots on underside of hind wings enclosed in a glossy band.....Blue Swallowtail (*P. philenor*).
7. Wings not glossy, upper side of hind wings with a row of blue spots, under side of wings rather faintly striped with black.
Tiger Swallowtail (*P. glaucus*), melanistic female.

FAMILY II. THE WHITES AND YELLOWS

1. Ground color of wings white.....2.
1. Ground color of wings orange or yellow.....6.
2. Forewings falcate, sharp pointed at tip, underside of hind wings marbled with greenish, an orange patch at tip of forewing in male.
Falcate Orange-tip (*Anthocaris genutia*). Central Section, early spring.
2. Not as in *genutia*.....3.
3. Forewings broadly bordered outwardly with black, albinistic females of some species of *Terias* and *Colias*. See under 6.
3. Forewings not broadly bordered with black.....4.
4. Wings unmarked, hind wings not buffy beneath.
Gray-veined White (*Pontia oleracea*). Mountains, rare.
4. Wings with some dark markings above.....5.
5. Black markings on upper side of wings consisting of the tip, one or two spots on forewing and one on hind wing, these sometimes wanting in spring specimens, hind wings buffy beneath.....Cabbage Butterfly (*Pontia rapae*).
5. Forewings with more than two black spots, hind wings unmarked (male), or extensively marbled with dusky and white (female).
Checkered White (*Pontia protodice*).
6. Wings almost wholly yellow, except a row of brown spots along the outer edge in the female.....Cloudless Sulphur (*Catopsilia eubule*).
6. Wings broadly bordered outwardly with black.....7.
7. With one or two pearly spots on underside of hind wings.....8.
7. With no pearly spots on underside of hind wings.....10.

8. Forewings coming to a sharp angle at tip, yellow on upper side of forewings bearing a rough resemblance to an animal's head.
Yellow Dogface (*Colias caesonia*).
8. Forewings rounded at tip....9.
9. Ground color of wings sulphur yellow...Clouded Sulphur (*Colias philodice*).
9. Ground color of wings orange.....Clouded Orange (*Colias eurytheme*)
10. Ground color of wings orange, spread over 1½ inches.
Bordered Orange (*Terias nicippe*).
10. Ground color of wings yellow, spread under 1½ inches....11.
11. A black band across fore wings near the posterior border....12.
11. No black band across forewings....14.
12. Under side of hind wings white.....Banded Sulphur (*Terias jucunda*). East
12. Under side of hind wings rusty....13.
13. Upper side of hind wings yellow.....Delia Sulphur (*Terias delia*). East
13. Upper side of hind wings white.....Elathea Sulphur (*T. elathea*). East.
14. Under side of hind wings yellow with brown spots..Little Sulphur (*Terias lisa*).
14. Under side of hind wings rusty.....Delia Sulphur, female.

FAMILY III. THE NYMPHS

1. Outer edge of both fore and hind wings strongly angled or jagged....2.
1. Outer edge of hind wings evenly rounded or nearly so....6.
2. Wings dark brown with cream colored borders.
Mourning Cloak (*Euvanessa antiopa*).
2. Wings reddish brown, the border darker....3.
3. Silvery mark on under side of hind wings divided into a curved mark and a dot, round black spots on upper side of forewings normally six.
Question-mark (*Grapta interrogationis*).
3. Silvery mark on under side of hindwings undivided, round black spots on upper side of forewings normally five....4.
4. Silvery mark on under side of hind wings tapered at both ends, under side of wings with grayish markings...Gray Comma (*Grapta progne*). Mountains.
4. Silvery mark on under side of hind wings expanded at both ends....5.
5. Under side of hind wings with greenish markings, wings very much jagged on the outer edges..Green Comma Butterfly (*Grapta faunus*). Mountains.
5. Under side of hind wings without greenish markings, wings only moderately jagged.....Comma Butterfly (*Grapta comma*).
6. Wings with numerous silvery spots on the underside....7.
6. Wings without silvery spots on the underside....10.
7. Forewings long and narrow, silvery spots on under side of hind wings elongate.
Gulf Fritillary (*Agraulis vanillae*).
7. Fore wings broad, silvery spots on under side of wings round....8.
8. Spread of wings 1½ inches...Myrina Fritillary (*Argynnis myrina*). Mountains.
8. Spread of wings 2½ to 3 inches....9.
9. Under side of hind wings with a broad yellowish band.
Great Spangled Fritillary (*Argynnis cybele*). Mountains.
9. Under side of hind wings with a narrow yellowish band.
Silver Spotted Fritillary (*Argynnis aphrodite*). Mountains.

10. Ground color of upper side of wings black or blackish, usually with some white markings.....11.
10. Ground color of upper side of wings some shade of brown or reddish brown...14.
11. Wings black, transversely banded with white, forewings long and narrow. Zebra Butterfly (*Heliconia charitonia*). South-east.
11. Wings not transversely banded with white.....12.
12. Upper side of forewings crossed by a bright red band. Red Admiral (*Pyrameis atalanta*).
12. Upper side of forewings without red band.....13.
13. Under side with numerous red spots....Red-spotted Purple (*Limenitis ursula*).
13. Under side of wings without red spots. Diana Fritillary (*Argynnis diana*), female. Mountains.
14. Upper side of wings without white markings.....15.
14. Upper side of wings with more or less white markings.....19.
15. Spread 3 to 4 inches, inner half of wings dark, the outer half orange in strong contrast.....Diana Fritillary, male.
15. Spread 2½ inches or less, colors not as in *diana*.....16.
16. Upper side of wings with 8 to 10 rounded black spots on each wing, spread about 1½ inches.....Bellona Fritillary (*Argynnis bellona*). Mountains.
16. Upper side of wings with not more than 4 or 5 rounded black spots on each wing, if more are present on the hind wings, there are none on the forewings.17.
17. Black spots as well as other markings present on upper side of forewings, color of wings mainly fulvous. Spread 2 to 2½ inches. Variegated Fritillary (*Euptoieta claudia*).
17. No round black spots on upper side of forewings, spread of wings under 2 inches.....18.
18. The dark color predominating on upper side of forewings. Silver Crescent (*Phyciodes nycteis*). Mountains.
18. The fulvous color predominating on upper side of forewings. Pearl Crescent (*Phyciodes tharos*).
19. Palpi very long, snout-like; outer edge of forewing strongly angled, wings fulvous centrally, black externally...Beaked Butterfly (*Libythea bachmani*).
19. Palpi short as usual, outer edge of forewing not strongly angled, if at all....20.
20. Wing veins all edged with black, ground color of wings reddish brown or orange .....21.
21. Wing veins not edged with black.....22.
21. Spread 3½ inches or more, no black line across middle of hind wings, two rows of white spots near the outer edge of both pairs of wings. Monarch Butterfly (*Danais plexippus*).
21. Spread under 3½ inches, a black band across middle of hind wings, one row of white dots near edge of wings.....Viceroy Butterfly (*Limenitis archippus*).
22. Wings with numerous white spots on the undersides of all wings, and at least on the upper side of the forewings also, but without any ringed eye-like spots.....23
22. Wings with few white spots on any one wing, but with eye-like spots on at least the under side of the hind wings.....25.
23. Spread about 3½ inches, the hind wings with very few, if any white spots on the upper side.....The Queen (*Danais berenice*). Eastern Section.

23. Spread 2 inches. Dark brown, the spots about equally numerous on all wings, above and below...The Baltimore (*Melitaea phaeton*). Mountains.
24. With one large eye-like spot on upper side of forewings, and two on the hind wings, the one on the forewings enclosed in the lower end of a whitish band, and repeated on the under side.....The Buckeye (*Junonia coenia*).
24. With no large eye-like spot on upper side of forewings.....25.
25. With two large eye-like spots on under side of hind wings.
Painted Beauty (*Pyrameis huntera*).
25. With not less than four small eye-like spots on under side of hind wings...26.
26. Ground color reddish brown, four or five small eye spots on under side of hind wings, spread 2¼ inches or more...Painted Lady (*Pyrameis cardui*). Local.
26. Ground color of wings dull brown, six or seven small eye spots on under side of hind wings, spread 2⅛ inches or less.
Gray Emperor (*Apatura celtis*). Central Section.

FAMILY IV. THE MEADOW BROWNS (*Agapetidae*)

1. Forewings with a large white or yellow patch.....2.
1. Forewings without any such patch.....3.
2. Two eye-like spots in white patch on forewings, spread of wings about 2. inches.....Blue-eyed Grayling (*Satyrus alope*). Mountains.
2. Often only one eye-like spot in patch on forewings, spread about 2½ inches.
Southern Grayling (*Satyrus pegala*).
3. Outer border of hind wings scalloped, spread about 2 inches.....4.
3. Outer border of hind wings not scalloped.....5.
4. Veins of outer part of forewings of male are noticeably pale and the round black spots between them have light wedge-shaped marks on their inner side, female with only two well developed black spots on upper side of forewings.....Southern Pearly-wing (*Debis creola*). Wake county
4. Veins on forewings not pale and without wedge-shaped light spots on their inner side. Three or four well developed black spots on upper side of forewings in both sexes.....Pearly-wing (*Debis portlandia*).
5. Upper side of wings with eye spots.....6.
5. Upper side of wings without eye-spots, spread less than 1½ inches.....7.
6. Forewings with two eye-spots above, spread about 1½ inches.
Little Wood Satyr (*Neonympha eurytus*).
6. Forewings with a row of black spots above, spread about 2 inches.
Eyed Brown (*Neonympha canthus*). Mountains.
7. Hind wings with a pearly or metallic patch on under side of hind wings but with no eye like spots.....Gemmed Brown (*Neonympha gemma*).
7. Hind wings with eye-like spots on under side.....8.
8. Eye spots on under side of hind wings round.
Carolinian Satyr (*Neonympha sosybius*).
8. Eye spots on under side of hind wings elliptical.
Georgian Satyr (*Neonympha phocion*).

FAMILY V. THE GOSSAMER-WINGED BUTTERFLIES (*Lycaenidae*)

1. Wings reddish brown above with black spots or many fine black lines.....2.

1. Wings not spotted above with black, nor with many fine black lines on the upper side....4.
2. Wings with four or five irregular black lines, extending across both pairs of wings on both surfaces.
Little Metal-mark (*Calephelis caenius*). Cumberland Co.
2. Wings spotted above with black....3.
3. Under side of hind wings with many small crescentic and circular fine white lines....The Wanderer (*Feniseca tarquinius*).
3. Under side of hind wings with small black dots.
American Copper (*Chrysophanus hypophleas*).
4. Wings with more or less blue on the upper side....5.
4. Wings without blue....10.
5. Hind wings evenly rounded, without thread-like tails....6.
5. Hind wings with thread-like tails....7.
6. Under side of hind wings with a row of orange crescents near the outer border....Scudder's Blue (*Lycaena scudderi*). Mountains.
6. Under side of hind wings without any orange markings.
Spring Azure (*Lycaena pseudargiolus*).
7. Hind wings evenly rounded with a single thread-like tail, color of upper surface of wings not bordered with black....Tailed Blue (*Lycaena comyntas*).
7. Hind wings with two tails or at least a second projection....8.
8. Blue little if at all evident on upper side of forewings, a red band on under side of wings....Least Purple Hairstreak (*Thecla cecrops*).
8. Blue largely present on both pairs of wings above, no red band on under side of wings....9.
9. Under side of abdomen orange, no white line on under side of wings.
Great Purple Hairstreak (*Thecla halesus*).
9. Under side of abdomen not orange, a white line on under side of wings.
White M Hairstreak (*Thecla M-album*).
10. Hind wings with thread-like tails....11.
10. Hind wings without tails, but often scalloped or uneven....15.
11. Under side of wings bright green, marked with brown and white.
Green Hairstreak (*Thecla damon*).
11. Under side of wings not green....12.
12. Under side of wings with a red band near outer edge.
Least Purple Hairstreak (*Thecla cecrops*), female.
12. Under side of wings without red band....13.
13. Under side of wings pearly gray with a single irregular white line on under side of hind wings....Gray Hairstreak (*Thecla melinus*).
13. Under side of wings dark brown with two or more series of broken white lines or series of lines....14.
14. Outer white lines on under side of hind wings continuous.
Banded Hairstreak (*Thecla calanus*).
14. Outer white lines on under side of hind wings broken.
Edward's Hairstreak (*Thecla edwardsi*). Polk Co.
15. Underside of hind wings with a row of orange spots.
Coral-banded Elfin (*Thecla titus*). Wake and Polk Cos.
15. Under side of wings without orange spots....16.

16. Under side of wings with numerous irregular black cross bars.
Banded Elfin (*Thecla niphon*).
16. Under side of wings not as in *niphon*.....17.
17. Under side of wings uniform rust red on its outer half.
Brown Elfin (*Thecla augustus*). Polk Co.
17. Under side of hind wings with pale scales on its outer half giving it a hoary appearance.....18.
18. Upper side of forewings grayish brown, under side of hind wings fairly uniform in color.....Hoary Elfin (*Thecla irus*). Mountains.
18. Upper side of forewings reddish brown on its outer portion, under side of hind wings with a pale outer portion and a dark inner portion, these sharply defined from one another.
Henry's Elfin (*Thecla henrici*). Polk and Wake Counties.

Note. In the preceding keys no distribution is given except of those species which are apparently confined to a part of the state, the others are known to be at least fairly well distributed throughout the state.

The sixth family of butterflies, the *Hesperidae* or Skippers, is left for another paper, the species being both numerous and hard to discriminate.

RALEIGH, N. C.

A THEOREM ON DOUBLE POINTS IN INVOLUTION

By J. W. Lasley, Jr.

A bilinear relation

$$axx' + bx + cx' + d = 0 \quad \ldots\ldots\ldots\ldots (1)$$

between x and x', in which a, b, c, d are known, may be regarded as a projective transformation of the points x of a line into the points x' of that line. Thus

$$5xx' + 2x + 3x' + 6 = 0 \quad \ldots\ldots\ldots\ldots (2)$$

sends the point $x = 1$ into the point $x' = -1$ and the point $x = -1$ into the point $x = 2$.

We ask ourselves can it happen that if $x = h$ is sent into $x' = k$, that $x = k$ is sent into $x' = h$. Such transformations are said to be of period two. They are called involutions. For example

$$xx' + 3(x + x') - 7 = 0 \quad \ldots\ldots\ldots\ldots (3)$$

sends $x = -2$ into $x' = 13$ and $x' = 13$ into $x = -2$.

One can convince himself that the noticeable difference between (3) and (2), namely that in (3) the coefficients of x and x' are alike, is a property which characterizes an involution. From this point of view an involution is given analytically by

$$axx' + b(x + x') + d = 0 \quad \ldots\ldots\ldots\ldots (4)$$

When for x = h the relation (1) demands $x' = k$, k is said to correspond to h. Ordinarily to k will not correspond h again. This will be so when, and only when, the projective transformation is an involution. In this event we may say that h and k correspond. The points —2 and 13 are seen to correspond in (3).

Consider now the involution

$$xx' - 7(x + x') + 33 = 0 \quad \ldots\ldots\ldots\ldots (5)$$

different from (3). Let us see whether (3) and (5) have a common pair of corresponding points. If so, x and x' must satisfy both (3) and (5). We have, then, xx', $-(x + x')$, 1 proportional to the two-rowed determinants obtained from the matrix

$$\begin{Vmatrix} 1 & 3 & -7 \\ 1 & -7 & 33 \end{Vmatrix} \quad \ldots\ldots\ldots\ldots (6)$$

by deleting in turn the first, second and third columns, that is

$$xx' : x + x' : 1 = -5 : 4 : 1 \quad \ldots\ldots\ldots\ldots (7)$$

Consequently x and x' are given by

$$x^2 - 4x - 5 = 0 \quad \ldots\ldots\ldots\ldots (8)$$

and are -1 and 5. We find upon testing these in (3) and (5) that they correspond in both involutions.

Let us inquire whether in an involution, like (3), there are points which correspond to themselves. If so, these are given by

$$x^2 + 6x - 7 = 0 \quad \ldots\ldots\ldots\ldots (9)$$

obtained from (3) by putting $x = x'$. These are here -7 and 1, and are called the double points of the involution. Similarly the double points of (5) are 3 and 11.

The question naturally arises as to what extent a choice of corresponding points determines an involution. Equation (4) appears to have three arbitrary constants, but it will become evident upon reflection that only the ratios of these are important. Clearly, if we knew two pairs of corresponding points, they would by (4) give us two homogeneous linear equations, which are usually just adequate for determining the ratios $a : b : d$. For instance, let us arbitrarily assign -7, 1 and 3, 11 as two pairs of corresponding points, and ask for the involution determined by them. The pair -7, 1 in (4) gives

$$7a + 6b - d = 0 \quad \ldots\ldots\ldots\ldots (10);$$

the pair 3, 11 in (4) gives

$$33a + 14b + d = 0 \quad \ldots\ldots\ldots\ldots (11).$$

From (10) and (11) we have $a : -b : d$ as the second order determinants obtained from the matrix

$$\begin{Vmatrix} 7 & 6 & -1 \\ 33 & 14 & 1 \end{Vmatrix} \quad \ldots\ldots\ldots\ldots (12),$$

by deleting in turn the first, second and third columns. In this way we obtain $a : b : d = 1 : 2 : -5$. Consequently, the involution determined is

$$xx' - 2(x + x') - 5 = 0 \quad \ldots\ldots\ldots\ldots (13),$$

whose double points are -1 and 5.

We have seen that the involutions (3) and (5) have just one pair of corresponding points in common, the pair -1, 5 given by (8). The double points of (3), namely -7, 1 and of (5), namely 3, 11, taken as two pairs of corresponding points determined (13), and involution different from (3) or (5). The common pair -1, 5 of corresponding points in (3) and (5) turned out to be the same as the double points of (13). We shall now show that this is not an accident of the particular involutions chosen, but follows from the nature of involutions.

In the two involutions (4) and

$$a'xx' + b'(x + x') + d' = 0 \quad \ldots\ldots\ldots\ldots (14).$$

the common pair of corresponding points are such that xx', $x + x'$, 1 are proportional to their cofactors in

$$\begin{vmatrix} xx' & x + x' & 1 \\ a & b & d \\ a' & b' & d' \end{vmatrix} \quad \ldots\ldots\ldots\ldots (15),$$

that is,

$$xx' : x + x' : 1 = (bd' - b'd) : (a'd - ad') : (ab' - a'b).$$

Consequently x and x' are given by

$$(ab' - a'b)\,x^2 + (ad' - a'd)x + (bd' - b'd) = 0 \quad \ldots\ldots\ldots (16).$$

The double points of (4) are given by

$$ax^2 + 2bx + d = 0 \quad \ldots\ldots\ldots\ldots (17),$$

those of (14) by

$$a'x^2 + 2b'x + d' = 0 \quad \ldots\ldots\ldots\ldots (18).$$

The involution determined by the two pairs of points in (17) and (18) is

$$\begin{vmatrix} xx' & x + x' & 1 \\ d & -2b & a \\ d' & -2b' & a' \end{vmatrix} = 0 \quad \ldots\ldots\ldots\ldots (19).$$

Its double points are given by

$$\begin{vmatrix} x^2 & x & 1 \\ d & -b & a \\ d' & -b' & a' \end{vmatrix} = 0 \quad \ldots\ldots\ldots\ldots (20),$$

or

$$(ab' - a'b)x^2 + (ad' - a'd)x + (bd' - b'd) = 0 \quad \ldots\ldots\ldots\ldots (21)$$

which is identical with (16). We have, then, established the theorem that *the common corresponding points in two involutions is the pair of double points in the involution determined by the double points of the given involutions.*

CHAPEL HILL, N. C.

THE COLLYBIAS OF NORTH CAROLINA

By W. C. Coker and H. C. Beardslee

Plates 1 and 4–23

Cap slightly fleshy and in most species drooping soon after maturity, often thin, expanded or rounded at maturity; margin even, at first incurved. Gills sinuate, adnate, adnexed, or free. Stem hollow or stuffed, cartilaginous, rooting. Spores white when fresh, smooth, in most species small. Volva and veil lacking. None is known to be poisonous and all the best known larger ones are valued edibles.

The Genus *Collybia* will be found fairly easy to distinguish among the white spored agarics. It is a little difficult to understand at first what is meant by "cartilaginous stem," and as is usual, some species referred to this genus are not clearly typical and might easily be referred to other genera. These will trouble the beginner. The largest of the genus, *C. platyphylla*, for example, has a thick fleshy stem and may well be looked for in *Tricholoma*. *Collybia confluens*, *C. stipitaria* and *C. zonata* might easily be referred to *Marasmius* at the start and they have in fact been transferred to that genus by some authors (see Atkinson, in N. Y. State Mus. Bull. **205–206**: 61. 1919). Kauffman, in his *Agaricaceae of Michigan*, retains them in *Collybia*.

The key which has been arranged has purposely been made as simple as possible, and will, it is hoped, be found practical. It covers the common species of the state, though more will probably be found as our fungous flora is better known. One species which is common in northern woods may be looked for in the mountains. It is *Collybia succosa* Pk. (*C. nigrescens* Quél., *C. atramentosa* Kalch., and *C. fuliginaria* Weinm.). It will be at once recognized from the watery drops which exude from the lamellae when cut and from the black hues which the flesh assumes when injured. *Collybia tenacella* (Pers.) Quél., *C. ventricosa* and *C. clavus* (L.) Quél., were reported from this state by Schweinitz or by Curtis. They are noted as doubtfully American by Murrill (N. Am. Flora **9**: 374–6. 1916). *Collybia detersibilis* B. & C., also reported by Curtis, is probably the same as *Clitocybe compressipes* Pk.

It will be noted that two species have been referred to European species not before reported from America. It may be said that this

has been done only after careful comparisons and correspondence with the best European authorities.

Unless otherwise stated all numbered collections are from Chapel Hill, N. C.

IMPORTANT AMERICAN LITERATURE:

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KEY TO THE SPECIES

Stem stout, striate, in a few cases stuffed, not velvety 1
Stem more slender, glabrous or pruinose, not distinctly striate or velvety 5
Stem distinctly velvety 11
1. Cap white or nearly so ..... *C. maculata* (1)
1. Cap red or chestnut brown, or reddish ochraceous 2
1. Cap gray, grayish brown or olive 3
2. Gills pure white; stem stout and enlarging downwards ..... *C. butyracea* (2)
2. Gills pure white; stem not stout and nearly equal ..... *C. dryophila* (3)
2. Gills spotted with red ..... *C. distorta* (7)
3. Cap viscid; stem with a long root ..... *C. radicata* (8)
3. Cap not viscid 4
4. Gills blackening when injured ..... *C. semitalis* (9)
4. Gills not blackening when injured ..... *C. platyphylla* (10)
5. Growing on decaying fungi, small, buffy tan ..... *C. cirrata* (12)
5. Growing on pine cones, small, threads at base white ..... *C. conigena* (13)
5. Growing on magnolia cones, threads at base buff ..... *C. conigenoides* (14)
5. Growing on thick beds of moss, small, brown ..... *C. clusilis* (22)
5. Not growing on cones or fungi 6
6. Cap less than 12 mm. broad; plant white all over ..... *C. alba* (15)
6. Cap larger; plant not pure white 7
7. Gills white or nearly so 8
7. Gills distinctly yellow ..... *C. exsculpta* (11)
7. Gills buff color, no tint of lilac ..... *C. exsculpta* (a form) (11a)
7. Gills brownish-lilac, or tan with tints of brownish-lilac 9
8. Growing on damp earth; plant small, the stem base with a mat of tawny

PLATE 4

COLLYBIA MACULATA. No. 1298.

hairs, color of cap dark brown.....*C. Earleae* (4)
8. Growing on earth, leaves or wood.....10
9. Growing on logs; gills crowded.....*C. myriadophylla* (6)
9. Growing on earth; gills not crowded and with spiny cystidia..*C. lilacina* (21)
10. Usually on leaves; cap center often rugose and always rugose on drying, color yellowish tan with center reddish; spores pip-shaped, about 3.5 – 4.5 x 6 – 9μ.....*C. nummularia* (5)
10. On earth, wood or leaves; cap center smooth and usually drying smooth; color pinkish tan or yellowish brown, the center darker; spores elliptic, about 3–3.8 x 5–7μ.....*C. dryophila* (3)
11. Cap distinctly viscid.....*C. velutipes* (16)
11. Cap rough-pubescent or squamulose.....12
11. Not as above.....13
12. Cap gray or brownish-gray, not zonate.....*C. stipitaria* (20)
12. Cap rich tawny color, zonate.....*C. zonata* (19)
13. Cap hygrophanous.....*C. confluens* (18)
13. Cap not hygrophanous.....*C. hariolorum* (17)

1. Collybia maculata A. & S.

PLATES 4 AND 23

Cap up to 8.5 cm. wide, usually 4–6 cm., convex, slightly viscid, smooth, even, dull or faintly shining, not at all striate, color nearly white or a light flesh-pink with darker areas and stains of pinkish-brick color which seem to be the result of rubbing. Center usually not darker than the margin. Flesh white or slightly pinkish, 1 cm. thick in center, thinner towards margin, dense and pliable, odor decidedly woody, taste bitterish and distinctly astringent, sometimes tardily so.

Gills colored like the cap and staining pinkish-brick on bruising; crowded, sinuate attached, narrow, 2–3.5 mm. deep, many short ones, none branched, margin eroded.

Stem 5–10 cm. long usually rather deeply rooted, white, even or slightly larger at either end, tough, elastic, fibrous, with a central cylinder that is lightly stuffed or hollow; surface minutely tomentose except at base where it is decidedly hairy; the hairs white or a very light cream color.

Spores (of No. 1298) cream color, elliptic, 2.9–3.8 × 4.2–5 μ. Easily distinguished from *C. dryophila* (which is nearest) by the brick-colored stains.

131. Low dense woods, Glen Burnie Farm, October 4, 1908.
594. Along branch below Howell's Spring, October 18, 1912. Spores cream color, elliptic, smooth, 3–3.7 × 4.7μ.

1298. On rotting pine log in woods south of athletic field, October 1, 1914. Photo.
1884. Under pines near old iron mine, October 3, 1915.
1939. In damp pine woods just south of athletic field, October 27, 1915. Spores smooth, subspherical, 3.6–4μ thick.
2370. Woods near Meeting of the Waters branch, June 5, 1916. Spores 3–4 × 4.5–7μ.
3011. Battle's Park just below Outdoor Theatre, April 19, 1918.
3187. Under pines by branch toward Meeting of Waters, October 5, 1918.

Asheville, on or around well decayed wood in mountain woods; rather rare. Beardslee.
Middle district (Schw.), woods. Curtis.

2. Collybia butyracea Bull.

PLATES 5, 6, AND 23

Cap up to 6 cm. wide, convex, sometimes umbonate, smooth, shining, color pinkish-buff, darkest in center. Flesh 2. 5 mm. thick at stem, very thin towards margin, soft.

Gills deeply depressed and angled at stem, nearly free, close, none forked, many short, up to 5.5 mm. wide near stem; white, margin strongly eroded.

Stem up to 6 cm. long, usually flattened and channelled, up to 5 mm. thick at cap, enlarging downward, smooth except near base which is incrassated with white mycelium, more or less obviously marked all over with longitudinal striations, color of cap, darkest below, flesh firm, elastic, fibro-cartilaginous, quite hollow.

Spores (of No. 1902) *not* white, exactly light buff of Ridgway, subpip-shaped, smooth, 3–3.7 × 5–6 μ.

On earth in woods, rare. There is a greasy look to the cap, which gives the plant its name.

I cannot find any quality that will hold good between this and all the forms of *C. dryophila*. In Chapel Hill forms occur with greasy-looking caps and slender equal stems, and Beardslee's photo. of *C. dryophila* on earth shows the stem enlarged below just as in *C. butyracea*. Also the slender stemmed plants of *C. dryophila* often show the stem distinctly lined when a lens is used. The spores of the two species as we have distinguished them here are identical.

1902. In pine and oak woods near Brockwell's, Battle's Park, October 17, 1915.
2431. Under shrubs in Mr. Woollen's yard, July 25, 1916. Spores elliptic, smooth, pointed at one end, 3–3.7 × 5.5–7.4μ.

PLATE 5

COLLYBIA BUTYRACEA. No. 1902.

PLATE 6

COLLYBIA BUTYRACEA. Photo by B.

Asheville, rather rare. Beardslee.
Middle district, rotten trunks. Curtis.

3. **Collybia dryophila** Fr.
Collybia subdryophila Atk.

PLATES 7, 8, AND 23

Plants solitary, gregarious or cespitose with the enlarged bases densely crowded.

Cap about 2.5–5.3 cm. broad, convex then expanded and uneven, usually a little depressed in or around the center, smooth, hygrophanous; in damp weather translucent and greasy looking, in dry weather opaque and dull or faintly shining, not greasy; color pinkish-tan or dull yellowish-brown, the center darker or with a lighter "eye." Flesh thin, 1.5–2 mm. thick near center, soft, color of cap or whitish, taste and odor like rotten wood (fungoid), not farinaceous.

Gills very thin, nearly or quite free, crowded, sinuate, the edges uneven, pure white or in age faintly creamy or pinkish-creamy; when bruised turning slowly to ochraceous. Looking at gills when fresh the color of the pileus showing through in some forms gives the effect of wine color.

Stem 4–7.5 cm. long, 2–4 mm. thick, equal (typically) except for a sudden enlargement at the very base, but often varying towards the enlarged base of *C. butyracea*, damp, smooth, white-tomentose near base, and with several string-like rhizomorphs; color like that of cap or lighter, pithy then hollow. If examined with a lens the stem may be seen to be distinctly striate with inherent lines of color, especially below.

Spores (of No. 80) deep cream, elliptic, smooth, 3–3.7 × 4.8–7 μ., most about 3.3 × 5.5 μ.

I can find no character that will sharply separate this from *C. butyracea*, and plants combining the characters of the two are often found. I am satisfied that these supposed species are forms of only one.

This is the commonest and most variable of our Collybias. In old plants the pileus is often pale, and it presents many variations in size and habit. It is, however, soon learned and recognized in all its

* There is a peculiar growth that has been often found on the cap and stem surface in America (not in Europe) that was named by Peck *Tremella mycetophila*. It is in the form of rather small pale globules or cushions of various size, that are plicate and soft. They are not, however, a *Tremella* as the basidia are club-shaped as in an agaric. Burt now thinks it an abnormal growth of the *Collybia* itself, but Miss Hone thinks it a true parasite. See Mycological Notes No. 47, p. 662. 1917.

disguises. One photograph is of the cespitose form on old wood, but it should be noted that it is often solitary or gregarious.

Collybia subdryophila was described by Dr. Atkinson from plants sent him from Chapel Hill by us. It seems to me to be one of the numerous forms of this variable species. His description is as follows (Ann. Myc. 7: 367. 1909):

"Plants dry, 5–9 cm. high, pileus 2–3 cm. broad, stem 5 mm., stout. Pileus smooth, purplish or pinkish-brown. Gills white, adnexed. Spores oval to subglobose, granular, then usually with a small oil drop, 3–4 μ, in diameter, rarely 5 μ, long. Stem cartilaginous, tough, hollow, equal. Belongs to Levipedes section, resembles somewhat *C. dryophila*, but differs especially in the spores. C. U. herb., No. 22634, mixed woods on hillside by Fern Walk near Sparrow's Pond, Chapel Hill, N. C., W. C. Coker, October 2, 1908."

For good illustrations see Mycologia 3: 101, pl. 40, fig. 8, 1911, and 4: 164, pl. 68, fig. 3. 1912.

80. On side of hill east of Tenney's, October 23, 1911.

1012. Among leaves in woods in Battle's Park, October 28, 1912. Spores cream color, 3.3–3.8 × 5–7.5μ.

1745. On trunk of red maple among growth of Porella, at foot of Lone Pine Hill, September 12, 1915. A depauperate form. Spores about 3.7 × 7μ.

2493. Gregarious to subcespitose in humus, grove at "The Rocks," May 9, 1917. Photo. Intermediate in character between *C. butyracea* and *C. dryophila*. Spores white at first, 3–3.3 × 5.5–6.7μ, exactly like those of *C. butyracea* No. 1902.

3049. Dense deciduous and also pine and deciduous woods, foot of Lone Pine Hill, May 18, 1918. Spores ovate-elliptic, white, smooth, 2.8–3.9 × 5.2–6.5μ.

3066. Strowd's lowground woods, on decaying stump, May 22, 1918.

3310. On a black gum log, June 7, 1919. One plant has on it a specimen of the growth called by Peck *Tremella mycocephala*. Painting.

3542. Mixed woods, Battle's Park, October 28, 1919. Cap very pale buff, center slightly darker. Gills and top of stem pale yellow, darker buff below.

Blowing Rock. Atkinson.

Asheville, "In scattered colonies on old leaf mould and old wood. Often in dense clusters." Beardslee.

Middle district, in woods. Curtis.

3a. **Collybia dryophila** Bull. A form.

We have a small, squat form of bare soil in shade that would hardly at first sight be referred to this species. It is single or cespitose;

COLLYBIA DRYOPHILA. Photo fly B.

PLATE 8

COLLYBIA DRYOPHILA. No. 2492-

the cap up to 2.5 cm., usually about 1.5 cm. broad, nearly plane or irregular, glabrous, not viscid, hygrophanous, brownish-leather color when wet, leather color or buffy leather when dry. Flesh concolorous; taste oily-woody, strong, odor same or slight. Gills rather close, sinuate, color of cap, 1–2 mm. wide. Stem 1.5–2.4 cm. long, 1–2 mm. thick, smooth, concolorous, tough, solid, firmly attached in the soil and bringing up a ball of earth. Spores (of No. 3237) white, elliptic, 2.9–3.7 × 4.1–5.5 μ, identical with those of the typical form.

2500. In humus soil under shrubs in Arboretum, May 11, 1917.

3237. In sparse weeds and grass under oaks, roadside home near Mebane, N. C. May 20, 1919.

3236. Bare soil, road in front of Dr. Battle's, May 15, 1919. This is just like No. 3237, except that it is abnormally squat and irregular and more cespitose; cap margin strongly recurved in most; odor and taste the same.

3240. On nearly bare soil under oak, hillside on Glen Burnie farm, May 21, 1919. Spores 3 × 4.2–5.5μ.

4. **Collybia Earleae** (Murrill) n. comb.
Gymnopus Earleae Murrill.

PLATES 9 AND 23

Cap 6 mm. to 3.3 cm. broad, convex, then plane or concave, smooth, dull, margin incurved until near maturity, sometimes striate; color pinkish buff or dark brown then wood brown; surface minutely puberulent all over when young. Flesh concolorous, tough; taste rankly moldy; odor faintly similar.

Gills not crowded, notched at stem, narrowly adnexed, becoming practically free at full maturity, narrow, 1–3 mm. wide, pale then nearly color of cap, with tint of pink.

Stem 1.5–3.3 cm. long, 1–4 mm. thick, tough and cartilaginous, hollow, granular-pulverulent, then smooth, color of cap or a darker reddish buff; attached to soil by a decided clump of tangled, tawny hairs which come up with it, bringing a ball of earth.

Spores (of No. 3052) white, smooth, pip-shaped, 2.3–3 × 5.2–6 μ.

This seems certainly *C. Earleae*, which is known only from the type locality—a creek bottom near Auburn, Alabama. The small size, dark color, growth on damp earth, pinkish-brown gills and particularly the dense clump of tawny hairs easily distinguish it.

3046. On damp ground, Strowd's lowground woods, May 5, 1918.
3052. Same locality as No. 3046, May 7, 1918.
3128. Same locality as No. 3046, May 18, 1918. Spores 3–3.8 × 5.8–7μ.
3130. Same locality as No. 3046, May 22, 1918.

5. Collybia nummularia Fr.
Collybia strictipes Pk.

PLATES 10 AND 23

This medium-sized plant grows generally in small tufts on rotting leaves in low woods. Cap up to 5.5 cm. broad, convex, then expanded, sometimes slightly depressed on one side, somewhat striate on margin, barely umbonate, yellowish-tan in color, often with tint of pink, the center almost brick red and usually a little rugose, often appearing water-soaked. The pileus sometimes shows concentric circles near the margin, evidently due to the plants being water soaked and drying in stages.

Gills close, and not very narrow, white or light flesh-colored, sinuate-attached, or sometimes free, not quite reaching the outer edge of the cap, many short ones.

Stem 3.5–7 cm. long, 3–7 mm. thick, cartilaginous, hollow, smooth, flesh-colored or whitish, darker at base, nearly equal, connected with extensive cream-colored mycelium that runs among the leaves.

Spores long, pip-shaped, white, smooth, 3.7 × 7.4–8 μ, characteristically pointed and bent at the mucro end.

Peck says of *C. strictipes* (Rep. **49**: 44. 1896): "From small unspotted forms of *C. maculata* this species may be distinguished by its even stem, less crowded lamellae and by the shape of its spores." From *C. dryophila* it is distinguished by the more yellowish cap with reddish, more or less rugose center, the more equal, paler, and more translucent stem, and by the longer, more pip-shaped spores. It is a common species and easily recognized. Kauffman has developed this species (as *C. strictipes*) from mycelium in leaf-mold brought into the laboratory and kept in a partially covered dish (Mich. Acad. Sci. Rept. **22**: 203. 1920).

82. On leaves near Howell's Branch, October 4, 1911.
83. Among leaves, Battle's Park, October 28, 1911.
354. On rotting leaves near Howell's Branch, October 11, 1911. Spores pip-shaped, mostly pointed and slightly bent at one end, 4 × 9μ.
584. Near Howell's Branch, October 18, 1912. Spores 3.5–4.5 × 6–9.5μ.

COLLYBIA EARLEAE. No. 3128.

PLATE 10

COLLYBIA NUMMULARIA. No. 628.

589. On leaves, below Howell's Spring, October 18, 1912. Spores 3.3–4 × 6–8.5μ, with mucro end pointed and bent.

628. On leaves near Battle's Branch back of Dr. Wilson's house, October 24, 1912.

Blowing Rock, Atkinson.

Asheville, abundant. Beardslee.

6. Collybia myriadophylla Peck.

Cap 2–5 cm. broad, thin and tough, broadly convex to plane and slightly depressed at the center, hygrophanous, brownish or grayish brown with a distinct lilac tinge when moist, paler when dry, minutely fibrillose.

Gills very crowded and narrow, adnexed, brownish lilac.

Stem slender, tough, 2–4 cm. long 1–2 mm. thick, colored like the cap, often compressed silky pruinose especially toward the rooting base.

Spores ellipsoid, 2 ×3-4 μ.

Growing on old logs. Rare.

This seems more common farther to the north. It is quite common in the coniferous woods of upper Canada. It is very distinct in its very crowded and narrow lilac gills. The texture of the plant is suggestive of *Marasmius*.

Asheville. Beardslee.

7. Collybia distorta A. & S.

PLATE 11

Cap 2.6–8 cm. broad, campanulate, then expanded, and in age with the irregular and contorted margin upturned; glabrous, hygrophanous, deep reddish brown, paler when dry, not viscid. Flesh toughish, pale-concolorous; taste of rotten wood; odor none.

Gills crowded, up to 6 mm. wide, mostly narrower, several times bra nched toward the margin; edges pubescent, thick; color a dilute tan, then strongly stained and blotched with reddish brown.

Stem short in ours, 2–4 cm. long, 5–10 mm. thick, often flattened; strongly channelled, inherently fibrous, the base whitish with mycelium and connected with stout white strands which run in the rotten wood.

Spores white, smooth, oval, 3.3–4.2 × 4.4–6 μ. (rather few in this collection).

3519. On a rotten log, October 26, 1919.

8. **Collybia radicata** Rehl.

PLATES 12 AND 23

Cap 3–10 cm. broad, expanded, usually umbonate and rugose, in center sometimes nearly plane; surface viscid, glabrous, varying from pale yellowish-brown or gray to deep blackish-brown, the margin lighter. Flesh thin, white, toughish, taste pleasant.

Gills white, rather distant, broad, adnexed to nearly free.

Stem very variable in length and thickness, often most slender when longest, 5–20 cm. long above ground, 3–13 mm. thick at stem, tapering upward, and extending deeply into the earth with a smaller root; surface glabrous or furfuraceous, striated and often grooved, about color of cap or lighter, darkest below; texture firm, stuffed.

Spores (of No. 1844) white, smooth, elliptic, 8–10.8 × 14.4–19 μ.

A very variable plant both in size and color, but always easily recognized by the long rooting extension of the stem. It is common in open woods, groves and shrubby borders through the summer and fall, and is edible. McIlvaine says it is sweet, pleasing in texture and delicately flavored. For a good illustration see Krieger in Nat. Geog. Mag. **37**: 398, 1920.

130. Campus in front of Alumni Building, September 21, 1908.
372. Open place west of athletic field, October 18, 1911.
472. Steep hillside on ground and on rotting tree roots in Battle's Park, September 30, 1912. Spores 11.8 × 15.2μ.
478. In open space back of South Building, October 2, 1912. Spores 11 × 18.5μ.
495. On steep hillside around rotting tree in Battle's Park, October 4, 1912.
1844. Battle's Park, north of Piney Prospect, September 20, 1915.

Asheville. Beardslee.
Blowing Rock. Atkinson.
Common in woods. Curtis.

9. **Collybia semitalis** Fr.

PLATES 14 AND 23

Cap convex, 2.5–5.5 cm. broad, convex except for a low umbo or nearly plane, hygrophanous, not viscid, rather silky-shining, inherently fibrous radially, at times minutely squamulose between center and margin, dark brown with a tawny tint, the center blackish and the margin soon so on withering or touching. Flesh 1.5 mm.

PLATE 11

COLLYBIA DISTORTA. No. 3519

PLATE 12

COLLYBIA RADICATA. No. 478.

thick near stem, pale brown, toughish, fibrous, taste and odor of raw meal.

Gills crowded, 4–5 mm. wide, broadly adnate and a little decurrent, not notched; brownish drab, the margins soon darker, black when bruised.

Stem 1.5–3 cm. long, 5–6 mm. thick, subequal, color and surface of the cap but rather darker; flesh concolorous, tough, firm, fibrous, stuffed and paler in center.

Spores (of No. 3869) white, smooth, oval, slightly pointed at each end, 3.7–4.2 × 7.4–8.5 μ.

Recognized by the rather small size; dark, smooth, inherently fibrous cap; dark, crowded, slightly decurrent gills, which change color when bruised, and by the farinaceous taste and odor.

Added below is Beardslee's description of this plant from Asheville:

Cap 1.5–6 cm. broad, hygrophanous, gray to deep smoky gray when moist, dingy gray to isabelline when dry, surface with darker fibrils giving it a streaked appearance, convex with the thinner margin incurved, then expanded and plane, flesh white, thin at the margin.

Gills white, quickly becoming yellow and then black when bruised, moderately close.

Stem 2–4 cm. long, 5–15 mm. thick, tough, white, changing color like the gills, stuffed but often hollow with age.

Odor rancid and unpleasant.

Spores usually ellipsoid, 7–9 × 5–6 μ.

Growing along paths, in bare ground in woods. This is a curious but altogether unattractive plant. I have found it only in wet weather after rains. Usually the plants are short stemmed and close to the ground, and dirty and sordid in appearance. They agree well with Bresadola's figure and description of *C. semitalis* to which I refer them. All my specimens agree in the quick change to yellow and then black, and all of them have the same disagreeable odor. Both of these characters are brought out in Bresadola's diagnosis.

It will be remembered that Bresadola has separated his plants into three closely related species, all of which were included by Fries under the one name. The spores of the Asheville plants are typically like those of his *C. semitalis* and the change of color and odor are as he describes. It is interesting, however, that some specimens had a few spores which were triangular as in his variety *trigonospora*, and in one plant they showed a tendency to become spindle shaped. In none was

there a change to blue, and then black. Some specimens were more like *Tricholoma* than *Collybia*.

It is hoped that more work can be done on these forms and their status definitely determined.

887. In pine and oak woods east of graded school house, October 4, 1913. Spores 3.7–4.6 × 7.4–9μ.
890. In pine and oak woods, sandy soil by edge of road, about 250 yards southeast of cemetery in woods, October 6, 1913.
3869. Mixed woods, back of athletic field, December 11, 1919.
3880. Mixed woods, Strowd's lowgrounds, December 13, 1919.

Asheville. Beardslee.

10. **Collybia platyphylla** Fr.

PLATES 1, 13, AND 23

Cap large, up to 12.5 cm. broad, plane and regular or considerably crimped, lobed and uneven, sometimes depressed in center; surface smooth, finely punctate under a lens, not viscid, a rich bay brown (about warm sepia, Ridgway) in center, fading to snuff brown on the margin. Flesh white, extraordinarily thin for the size of the plant, only 3 mm. thick near the cap, and fading to a mere transparent membrane near the margin.

Gills deeply sinuate, barely reaching the stem at top, distant, sometimes much crumpled and ridged on faces, varying greatly in width in the same plant, some 2 cm. wide in the center, while other narrow ones running between are only a few mm. wide; color nearly white or with a slight flesh tint.

Stem stout, about 5–10 cm. long, 1.5 to 2.3 cm. thick at top, somewhat larger below, stuffed, then usually hollow; surface even and smooth, striate, white at top, brownish below; flesh white, firm.

Spores white, smooth, oval to short-elliptic, 6.8–7.6 × 7.6–8.5 μ.

Edible, but not so good as many others.

1263. In grass just east of Old West Building, campus, U. N. C., September 25, 1914. Painting.
1833. In humus, woods by branch southwest of Rocky Ridge Farm, April 20, 1915. Spores creamy in bulk, subspherical to ovate, smooth, 4. 3–5. 8 × 6.3–8μ. Surface of cap brownish-gray, with whitish flecks from the cracking superficial layer.
2045. In grass near oak tree north of Alumni Building, June 9, 1916. Also occurs near stump north of President's house.
2509. In same spot as No. 2045, June 8, 1917.

COLLYBIA PLATYPHYLLA. No. 1833.

3276. On a rotting oak stump in Battle's Park, June 1, 1919. A remarkable form of *C. platyphylla*. Cap drooping with the margin crimped inward, about 11 cm. across below, and hanging down about 10 cm., glabrous, but cracked into inherent scales over all but margined half or third. Stem very long, 24 cm., 1.7 cm. thick; fibrous, tough. Spores smooth, ovate, 5.9–6.6 × 7.7–8.1μ.

Blowing Rock. Atkinson.
Asheville. Beardslee.
Low and middle districts, on rotten wood. Curtis.

11. **Collybia exsculpta** Fr.
Collybia colorea Pk.

PLATE 14.

Cap 2–4 cm. broad, rounded convex to broadly campanulate, with the center a little prominent; hygrophanous, yellow, with the disk often reddish or brownish, minutely fibrillose; margin thin, exceeding the gills, even.

Gills yellow, close, narrow, sinuate adnexed, usually turning red in drying.

Stem slender, 2–4 cm. long, 3–5 mm. thick, colored like the cap, hollow, glabrous.

Spores ellipsoid, 4–6 × 3–3.5 μ.

On old logs; not rare.

This is without question Peck's *C. colorea*. Our specimens have been submitted to Bresadola and approved as *C. exsculpta*, which is said to be rare in Europe. The gills usually change to red in drying, but I have had undoubted specimens in which this is not the case. Occasionally I have found specimens in which the growing plant were red. This, I take it, is Peck's var. *rubescentifolia*. From the peculiar color and its habit of growing on logs this species would be taken at first sight for *Flammula*.

Asheville. Beardslee.

11a. **Collybia exculpta** (a form)

PLATES 15 AND 23

Cap 1. 6–2. 6 cm. broad, convex with a depressed center, then expanded with depressed center, glabrous, hygrophanous, not viscid, very faintly striatulate near the margin when soaked, color about ochraceous tawny when soaked, a paler cream-buff to chamois when

not soaked, the center at times a little darker, the thin margin soon withering to nearly black. Flesh very thin, about 0.6 mm. thick near stem, taste woody and a little bitter, odorless, concolorous.

Gills crowded, color of unsoaked cap, in places becoming distinctly lilac in drying, sinuate, about 2–3 mm. wide.

Stem concolorous, 2.3–3 cm. long, 1.3–3.5 mm. thick, nearly equal, base with white mycelium; mostly glabrous, a large hollow, toughish (cap rather tender).

Spores (of No. 4543) white, smooth, subspherical, 3.5–4 × 3.7–5.5 μ, no cystidia. Basidia long-clavate, about 6 μ, thick, 4-spored. Hymenium about 29–33 μ, thick. Threads of the gill trama parallel, narrow toward the margin, more swollen toward the cap.

I am considering this a form of *C. exsculpta*, but the color is buff, not yellow or reddish-yellow and the gills are not bright suphur yellow. Also it does not grow on decaying wood but on the ground.

1735. In earth by path west of Meeting of Waters, September 10, 1915.
4543. On very rotten pine log, Strowd's lowgrounds, July 26, 1920.
4597. On rotting oak wood, swamp of Bowlin's Creek, July 30, 1920. Spores 3.7–4.5 × 4.5–7.4μ.

12. **Collybia cirrata** Fr.

Agaricus cirratus Pers. Abs. Myc. 2: 53. 1799.

PLATES 1, 16, AND 23

Cap 7–15 mm. broad, slightly umbonate, depressed-umbonate, or only depressed, expanded; the margin curved; glabrous, hygrophanous, not viscid, buffy tan, the margin pale, and center darker. Flesh about 0.5 mm. thick, toughish, concolorous, almost odorless, tasteless.

Gills crowded, less than 1 mm. wide, linear, slightly notched at stem, nearly white or concolorous.

Stem 0.8–2.5 cm. long and up to 2 mm. thick, narrowed above, or equal, about color of cap or darker, covered below with a conspicuous dense mat of long, cottony, white or whitish, more or less radicating fibers which may extend with reduced length nearly to the top if well protected; usually only scurfy above.

Spores (of No. 3491) white, smooth, oblong-ovate, 2.2–2.5 × 3.7–4 μ.

This is certainly *C. cirrata*, agreeing in all respects with Persoon's original description which is as follows (translation):

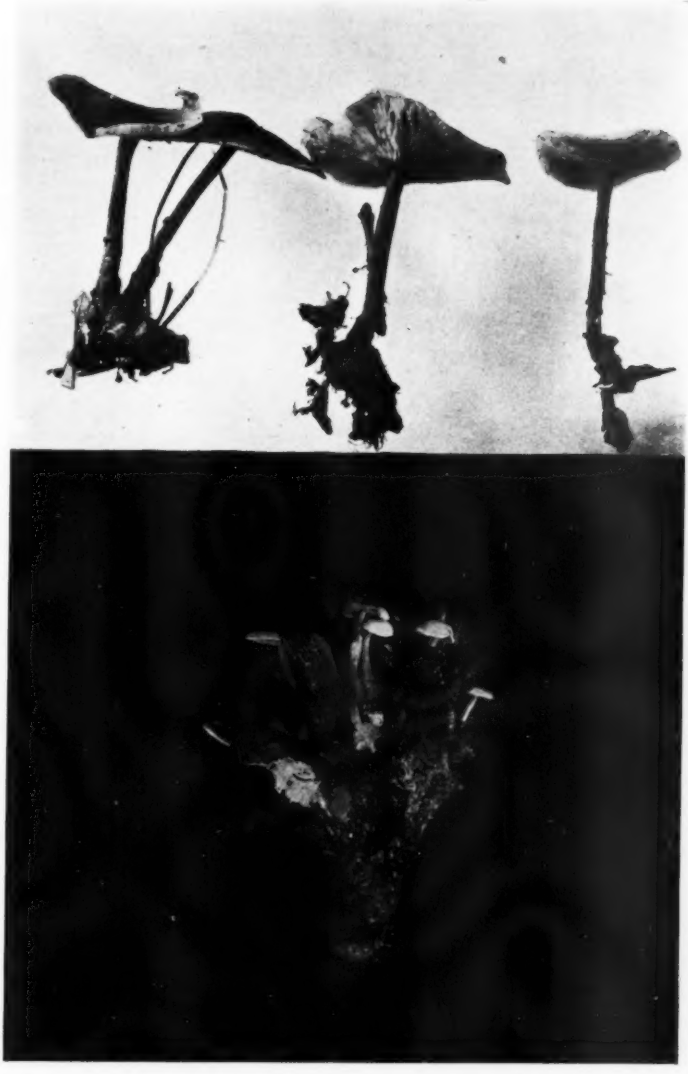
PLATE 14

COLLYBIA EXSCULPTA. Photo by B. [upper left].
COLLYBIA ALBA. Photo by B. [upper right].
COLLYBIA SEMITALIS. Nos. 3869 & 3880 [below].

PLATE 15

COLLYBIA EXCULPTA, A form. No. 1735.

PLATE 16



COLLYBIA HARIOLORUM. Photo by B. [above].
COLLYBIA CIRRATA No. 3941 [below[.

"Small, gregarious, cap subpapillate, plane, whitish; disk subrufescent, gills crowded, white; stem rather long, slender, rufescent covered with long fibrillose rootlets.

"Habitat. Among dead leaves in autumn, truly a parasite, especially on dying Agarics.

"Stems 1½ inches long, ½ line thick at base and sending out sparingly from the sides fibrillose rootlets sometimes 1½ inches long. Gills narrow, even, subdecurrent. Cap about 2–3 lines broad, plane to convex, subumbilicate, ½ line thick."

Murrill thinks this the same as *C. tuberosa* (N. Am. Flora **9**: 374. 1916) and he may very well be right. This form, however, has no tuber and the dense mat of hairs is not mentioned for *C. tuberosa*. *Agaricus* (*Collybia*) *tuberigenus* B. & C. is probably this. There is a collection from Hillsboro, N. C., in the Curtis Herbarium. It is hairy at the base like our plants and also has small tubers. It seems to be growing from earth rich in humus "under cedars."

Beardslee's notes on the Asheville plant are as follows:

This species and its close relative *C. tuberosa* seem to need further study. True *C. cirrata* was found at Asheville answering well to the common description. The more common form, however, grew in masses from old decaying fungi arising in almost every case from yellowish sclerotia, but also having a dense mass of white fibrillose roots. If the presence of a sclerotium is decisive our plant is *C. tuberosa*. Bresadola considers this plant *C. cirrata* and writes that the differences are "exactly as shown in Cooke." The main difference in Cooke's figure is in the sclerotia which are deep brown or black in *C. tuberosa* and yellow in *C. cirrata*. According to this view our Asheville plants are the latter species. It seemed possible that the color of the sclerotia might depend upon their age, the yellow color being characteristic of the newly formed sclerotia and the dark brown or black indicating older ones. Some attempts were made to test this theory but no decisive results secured.

3491. On a dead and black, but still firm and tough, Thelephora, on earth near north branch of Meeting of the Waters, October 16, 1919.

3743. On a dead agaric in pine woods north of Meeting of Waters, November 12, 1919.

Asheville. Beardslee.

13. Collybia conigena Fr.

PLATES 17 AND 23

Cap about 1.5–20 mm. broad, about 270 μ thick, very nearly plane, but with a slight depression in the center, the edge turned up slightly in older specimens, surface glabrous, light brownish-tan, or the center pinkish, minutely pubescent. Threads of flesh very irregular and knotty.

Gills almost white with a brownish tinge, nearly or quite free, some branched, quite narrow toward the margin. Threads of gill flesh 3.7 μ thick.

Stem about 2.5–5 cm. long, very pale, lighter in color than the cap or gills, minutely pubescent (velvety) at maturity above and with long white hairs at the base which attach it to the cone. These threads are very long and conspicuous rhizomorphs that look like stiff cotton threads and are very peculiar. They may extend from as much as the lower third of the stem.

Spores (of No. 3503) white, extremely minute, oblong, about 1.5–2 × 3–4 μ. Basidia about 3.7 μ thick and 13 μ long. Cystidia only on margin of gills, 6.6–9.3 μ at thickest part, about 15–25 μ long.

Easily recognized from its habit of growth on pine cones. While *C. esculenta* and *C. conigena* are said by Bresadola to have much larger spores, this is not borne out by the more recent European monographs. Lange (l. c. p. 18), Ricken (l. c. p. 414), and Sartory and Maire (l. c. p. 176) all describe the spores to be substantially as in our American plants. Their creeping stems which are hairy on the rooting portion could not separate our plants. It is only in the spores that a marked difference appears. *Collybia esculenta* is listed by Schweinitz from this state. For comparison of this and *C. conigenoides*, see the latter species.

84. On pine cone, October 20, 1911.
2948. On cone of *Pinus echinata*, October 15, 1917.
3503. On decaying pine cones, October 25, 1919.

Asheville. Beardslee.
Low district, rotting pine cones. Curtis.

14. Collybia conigenoides Ellis.

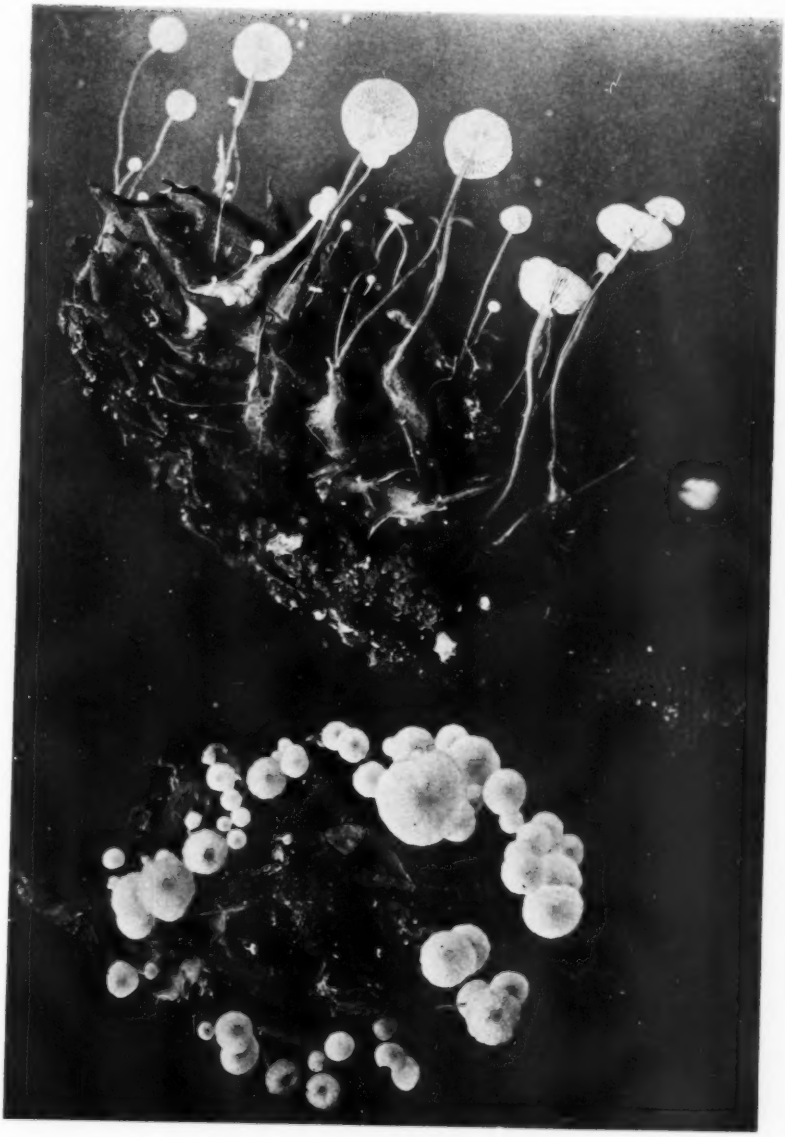
PLATES 18 AND 23

Cap 3–15 mm. broad, convex then nearly plane, at times depressed in center, striatulate, very finely pubescent, a little viscid, buff in center, paler toward margin; the cap surface composed of large swollen cells through which project the short hairs which are about

PLATE 17

COLLYBIA CONIGENA. No. 3503.

PLATE 18



COLLYBIA CONIGENOIDES. No. 3545.

6–7.5 μ thick at base and of variable length up to 55 μ. Flesh less than 0.5 mm. thick, nearly tasteless and odorless, toughish; threads of flesh about 3.7 μ thick.

Gills white or palely concolorous, rather close, ventricose, 1.5 mm. wide in center, rounded at stem and slightly adnexed, not veined or branched.

Stem 1.5–4 cm. long, 0.5–0.9 mm. thick, finely puberulent all over like the cap, except in the basal region which is covered for some distance by long, woven, fine buff hairs which bind the stems together; color a clear ochraceous buff all over except for the abruptly whitish tip; tough, hollow.

Spores minute, smooth, elliptic, pointed at one end, 2.2–2.9 x 5–6.3 μ. Basidia 4-spored, about 4.4 μ thick and 18 μ long. Cystidia present, contracted above the swollen body.

Mostly cespitose, but some single. It approaches very closely to *Marasmius*, reviving quite well in water.

This is certainly *C. conigenoides*, every character agreeing with the original description (Bull. T. B. C. **6**: 76. 1876). We have examined a collection determined by Ellis and distributed as No. 3503 in Ellis and Everhart North American Fungi on cone of *Magnolia Fraseri* from Nuttallburg, W. Va. (Herb. Dept. Agr., Washington). Although in bad condition this specimen is without doubt the same as ours, with the long buff hairs conspicuous around the stem. The species is different from our plant on pine cones which we are calling *C. conigena*. The latter has smaller spores and basidia, gills branched in part, a paler stem, with white, not buff threads below, and no bladder-like cells on the cap surface.

The plant from Michigan on pine cones referred by Kauffman to *C. conigenoides* cannot be our species on magnolia cones as the former has a white stem with white hairs at the base and shorter spores.

3545. By path in Arboretum on fallen magnolia cones, October 28, 1919. Photo.

15. **Collybia alba** Pk.

PLATE. 14

Cap 6.5–11 mm. broad, rounded-convex, white, glabrous.
Stem 1.7–2.6 cm. long, 2 mm. thick, pure white, glabrous.
Gills broad, ventricose, nearly free.
Spores 4–5 × 3 μ.
Growing on old mossy logs and stumps. This small white species

is found frequently in the summer, and has been referred to Peck's species with which it seems to agree. The dried plants become dingy as they dry, as noted by Peck.

Asheville. Beardslee.

16. **Collybia velutipes** (Curt.) Fr.

PLATES 19 AND 23

Plants densely crowded and imbricated or somewhat scattered, growing on logs.

Cap up to 4.5 cm. broad, very irregular in shape and surface, ridged and often deeply pitted, general outline rounded or nearly plane; surface very glutinous and viscid, smooth, color a strong dull red (about burnt sienna) in center, shading out to a yellowish-red on margin; in old wet plants a deeper blackish-red. Flesh light reddish-yellow (about color of gills), about 3 mm. thick near stem, quickly thinning to less than 1 mm., tasteless or sweetish.

Gills moderately close, sinuate attached, with a broad, deep tooth near stem, about 8 mm. wide at the tooth and 4 mm. wide beyond; color a light reddish-yellow, about pale yellow-orange of Ridgway, lighter when young.

Stem central or somewhat lateral, about 2. 5 to 5 cm. long, usually strongly flattened at top or to full extent, about 5 to 8 mm. wide at cap, tapering downwards, and usually fused with others at base into a dense clump, surface densely short-tomentose, almost velvety; color of gills at top, dark reddish-brown elsewhere, texture tough, almost cartilaginous at surface, more fibrous inside; solid or partly hollow.

Spores (of No. 1507) white, very abundant, elliptic, smooth, 3.4 × 5.1–8.5 μ.

This is one of the good edible mushrooms and it may be had often in any of the winter months. We find it in Chapel Hill only in cool weather. For an elaborate account of the plant with ten plates see Stewart in Bull. No. 448, N. Y. Ag. Exp. Sta., Geneva, Feb.1918; also Biffen in Journ. Linn. Soc. **34**: 147. 1899.

For other illustrations see Mycologia 1: 39, pl 3. 1909; Krieger. Nat. Geog, Mag. **37**: 398. 1920.

1507. On end of hickory log in grove behind Memorial Hall, December 9, 1914.
2013. On a charred oak stump, southwest of athletic field, December 18, 1915. Spores elliptic, smooth, 3.2–4 × 5.5–8μ.

PLATE 19

COLLYBIA VELUTIPES. Photo by B.

Asheville. Beardslee.
Middle and upper districts, on rotting logs. Curtis.

17. **Collybia hariolorum** Fr.

PLATE 16

Cap 2–5 cm. broad, broadly campanulate, becoming expanded, and at length nearly plane with the center a little prominent, pale tan or pale rufescent at first, becoming white with age, glabrous, striate on the margin when moist; flesh white, thin, especially on the margin; odor when crushed strong and unpleasant. Taste disagreeable.

Gills white, narrow, closely crowded, adnate with a distinct sinus.

Stem 2–4 cm. long, 2–4 mm. thick, hollow, slightly enlarged at the base, everywhere covered with white villous down, which is longer and more marked at the base, the extreme base usually curved and attached by an abundant white mycelium to the leaves in which it grows.

Spores 4–6 × 2.5–3 μ.

Somewhat gregarious, on old leaves in woods.

This species appeared quite frequently in late summer at Asheville. It is suggestive of *C. confluens*, and may easily be taken for it. As found at Asheville it is more nearly white than *C. confluens*, has a shorter stem, and is not inclined to occur in the dense clusters which are characteristic of *C. confluens*. The rather disagreeable odor is also a mark of distinction.

Asheville. Beardslee.

18. **Collybia confluens** Fr.

Marasmius confluens in N. Am. Flora **9**: 269. 1915.

PLATES 20 AND 23

Cap 1.3–4.6 cm. broad, convex then expanded, the center broadly compressed, the margin curved and striatulate when moist; hygrophanous, reddish-brown and viscid when wet, leather color when dry. Flesh toughish, concolorous, about 1 mm. thick in center; taste and odor slight.

Gills moderately close, up to 4 mm. broad, rounded at stem and adnexed, color of dry cap.

Stem 4–6 cm. long, finely white pubescent above, the threads longer and more cottony below and often binding several together,

color of cap when shown through the pubescence; tough, often compressed; hollow.

Spores white, smooth, elliptic, pointed, 2.5–3.7 × 6.2–7.4 μ.

3533. Mixed woods back of cemetery, October 26, 1919.

Blowing Rock. Atkinson.
Asheville. Beardslee.
Middle and upper districts, among rotten leaves. Curtis.

19. **Collybia zonata** Pk.

PLATES 21 AND 23

Cap up to 3. 6 cm. broad, convex, or nearly flat with a broad umbo, a sharp depression in the center (umbilicate) at all ages, flatly hemispheric when young, with the margin strongly incurved; surface conspicuously clothed with roughish hairs of a rich tawny color, the hairs usually pinched into groups and flattened. Flesh thin, tough, white, taste sweetish, of a disagreeable, fishy nature, odor strong and of the same nature, and persisting long after drying. Occasionally the odor is absent, as in No. 2658.

Gills white, rather close, narrow, about 1.5 mm. wide, quickly rounded at the stem and barely reaching it at the upper angle.

Stem slender, even, up to 5 cm. long, about 1.5 to 2 mm. thick, tough and strong, with a small irregular hollow about the size of a needle; surface covered with similar hairs as the cap and of the same color.

Spores white, elliptic, smooth, 4.5–5.4 × 6.4–7.2 μ.

The plants are cespitose from decaying bits of twigs, etc., on the ground and are remarkable for their penetrating odor, somewhat resembling the fishy smell around old wharves, only more acid. This is not mentioned by others.

Not found at Asheville by Beardslee and apparently new to the state. For a discussion of this and related species see Atkinson N. Y. State Mus. Bull. **205-206:** 61. 1919. For other illustration see Mycologia **4**: pl. 56, fig. 8. 1912.

1577. From twigs, rootlets, old beech fruits, etc., on ground, New Hope Swamp, June 26, 1915.
1899. On a rotten root, woods at foot of Lone Pine Hill, October 17, 1915.
2241. On hull of *Hicoria ovata*, swamp of New Hope Creek, June 24, 1916.
2568. By path in woods along Battle's branch, July 2, 1917.

PLATE 20

COLLYBIA CONFLUENS. No. 3533.

PLATE 21

COLLYBIA ZONATA. No. 1577.

2658. On rotten oak log, low damp woods by Battle's branch, July 12, 1917. The characteristic odor of the type was absent when fresh, but was slightly noticeable when dry. Taste faint, but unmistakably that of type. Other plants with very strong characteristic taste and odor were growing on the same log with this, but several feet away.

3112. New Hope Swamp on decaying bark, June 23, 1918.

20. Collybia stipitaria Fr.

Marasmius stipitarius (Fr.) Atk. and House.

Agaricus scabellus Alb. and Schw.

PLATE 23

Cap 5–12 mm. broad, convex, depressed a little around the center which is itself concave, roughly fibrous, that is, the inherent fibers forming irregular elevated ridges and near the margin pinched into squamules, pale tan to gray or brownish-gray, the center (in No. 3370) abruptly a much deeper gray-brown; texture of cap and stem tough and persistent; taste and odor none.

Gills rather distant, about 1 mm. broad, abruptly sinuate at the stem and nearly or quite free, pale-creamy white, the margins toothed.

Stem 2–5 cm. long, 0.5–1 cm. thick, equal, spongy-scurfy all over, inserted, i. e. disappearing into the substratum and not arising from superficial mycelium; about color of cap center, the tip shading to tawny.

Spores smooth, oval to elliptic, 5.1–6.2 × 8.9–10.4 μ. Cystidia acute to mucronate, simple.

Easily recognized by the fibrous-squamulose cap, dark center, nearly free gills and spongy stem surface. It is distinguished from *C. zonata*, which is near, by the smaller size, absence of fishy smell and longer spores. For discussion of this and related species see Atkinson in Bull. N. Y. St. Mus. **205–206**: 61. 1919. Massee gives measurements of *C. stipitaria* as: cap 4–11 mm. across and stem 1–2 in. long. For other illustration see Lloyd, Mycological Notes **1**, No. 5: 42, fig. 15, 1900.

3370. On herbaceous debris, grove in front of Gimghoul Lodge, June 26, 1919.

Asheville. Beardslee.

Middle and upper districts, on decaying trunks. Curtis.

21. **Collybia lilacina** n. sp.

PLATES 1, 22, AND 23

Solitary or gregarious and at times subcespitose, rather often with little undeveloped ones attached to the stem bases of mature ones. Cap up to 7.5 cm. usually about 4–5.5 cm. wide, hygrophanous, decidedly or very slightly umbonate, somewhat uneven, expanded, margin striatulate when moist, even or nearly so when dry, flat or bent down; surface smooth, like fine leather in appearance, the marginal third often rugose in youth, the wrinkles disappearing; color tan with the center decidedly deeper and usually with a tint of lilac at maturity. Flesh thin, only 1. 8 mm. thick at stem, whitish except at center, which is brownish-lilac, tough, almost tasteless.

Gills rather distant, variable in attachment just as in *Clitocybe compressipes*, sometimes deeply sinuate, most of them barely attached and not at all decurrent, again squarely adnate in part and sinuate in part and some slightly decurrent by a tooth, very easily separating from the stem when attached, about 5–8.5 mm. wide, broadest near stem, color a pallid tan or bright tan, then darker with brownish-lilac tints and smoky on drying, many short, none branched. The surface of the gills is set with spiny cystidia which project about 20–25 μ.

Stem very variable in length even in plants of the same size, up to 11 cm. long and 6.5 mm. thick at cap, nearly equal, usually twisting in drying and becoming lined from top to bottom, tough and semicartilaginous, firm, elastic; surface pruinose and often lined above, smooth below, the very base enlarged and tomentose with the fine white mycelium; color of cap, lilac tinted at maturity especially above white at base; flesh strongly brownish-lilac, deepest colored within, a large hollow cylinder in center from top to bottom.

Spores (of No. 1818) white, elliptic, smooth, 5.2 × 7.8 μ.

Very young plants are nearly black, but soon become paler. The lilac tints do not appear until maturity and deepen afterwards. This change is peculiar and constant. Smaller specimens of the species have very much the general appearance of *Marasmius oreades*, but differ in the smooth hollow stem, tendency to lilac tints in all parts at and after maturity, in not reviving well when moistened and in the much larger size attained at times. The habit also is different, our plants being solitary or sparsely gregarious, and growing in woods and shrubbery and on bare earth, not in open grassy places. It also

PLATE 22

COLLYBIA LILACINA. No. 3288. Photo of drawing, to show size.

seems near *C. nigrodiscus* Pk. I am inclined to think this is the plant listed by Curtis as *M. plancus*, Fr., which has a similar habit and size and has a hollow stem, but *M. plancus* differs in its narrower gills and downy stem, and in absence of lilac tints. In size, shape, and thickness of flesh, *Mycena Zamurensis* Pat. and Gail. from Venezuela (Bull. Soc. Myc. Fr. **3**: pl. 8. 1887) recalls our plant, but is excluded by the absence of lilac tints and differently shaped spores. I have looked through the Curtis herbarium under *Marasmius* and *Collybia* but could find nothing like this.

1752. In damp shaded spot in soil among weeds and grass, woods at foot of Lone Pine Hill, September 12, 1915.

1818. One plant. On dry shaded path in Arboretum, northeast side, September 17, 1915. Stem eccentric; gills almost triangular, wide in center, pointed at stem and just reaching it, distant, veined at cap, rather light brownish-drab with a tint of lilac. Stem granular-pruinose above, smooth elsewhere, tough, 2.5 cm. long, hollow; cap 3.5 cm. wide.

2193. Woods below rock wall, south of Peabody building, June 21, 1916. Cap about 3 cm. broad, strongly convex, umbonate, smooth, appearing slightly tomentose under a lens, hygrophanous, fleshy-buff color, darker in center; margin thin, even, becoming brownish-lilac. Spores white, smooth, elliptic, pointed at one end, 3.7–4.4 × 5.5–8μ.

2810. Among shrubs near wall, east side of Arboretum.

3288. Under *Magnolia* in Arboretum, June 4, 1919.

3290. Under *Magnolia soulangeana* in Arboretum, June 4, 1919. Fine plants, up to 6.5 cm. in diameter. Painting.

4331. Under shrubs in Arboretum, June 24, 1920. Spores variable, smooth, elliptic, 4–5.5 × 6–9μ.

22. **Collybia clusilis** Fr. (sense of Schroeter)
Mycena palustris (Pk.) Sacc.

Cap up to 1 cm. broad, very smooth, convex, not umbonate or umbilicate, brownish-olive or buffy-brown (Ridgway), paler when young, very thin and delicate but not striate.

Gills pale yellowish-brown, distant, slightly decurrent, not sinuate, less than 1 mm. wide, only about 20 to 25 in number and a few short ones.

Stem slender, about 3 cm. long, color of gills, smooth, hollow, extending deeply into the moss and there covered with mycelial strands.

Spores white, subspherical to elliptic, smooth, 3.5–6 × 4–9 μ.

This very pretty little plant seems to be confined to thick beds of moss.

Notes by Beardslee follow:

Cap 0.5 cm. to 2 cm. broad, rounded convex, at times slightly raised at the center, becoming more expanded with age and somewhat depressed, hygrophanous, pale brown or brownish-olive, paler when dry, and becoming opaque, and with a slight silky luster, margin thin, striatulate when moist, even when dry; flesh thin.

Stem slender, weak, 3–6 cm. long, a little lighter in color than the cap, attached by abundant white mycelium to the mosses in which the plant grows, smooth, and hollow.

Gills grayish brown, rather distant, adnate, rather narrow, venous connected.

Spores elliptic, 7–9 by 4–5 μ.

Odorless when fresh, but developing a slight disagreeable odor. Growing in beds of sphagnum.

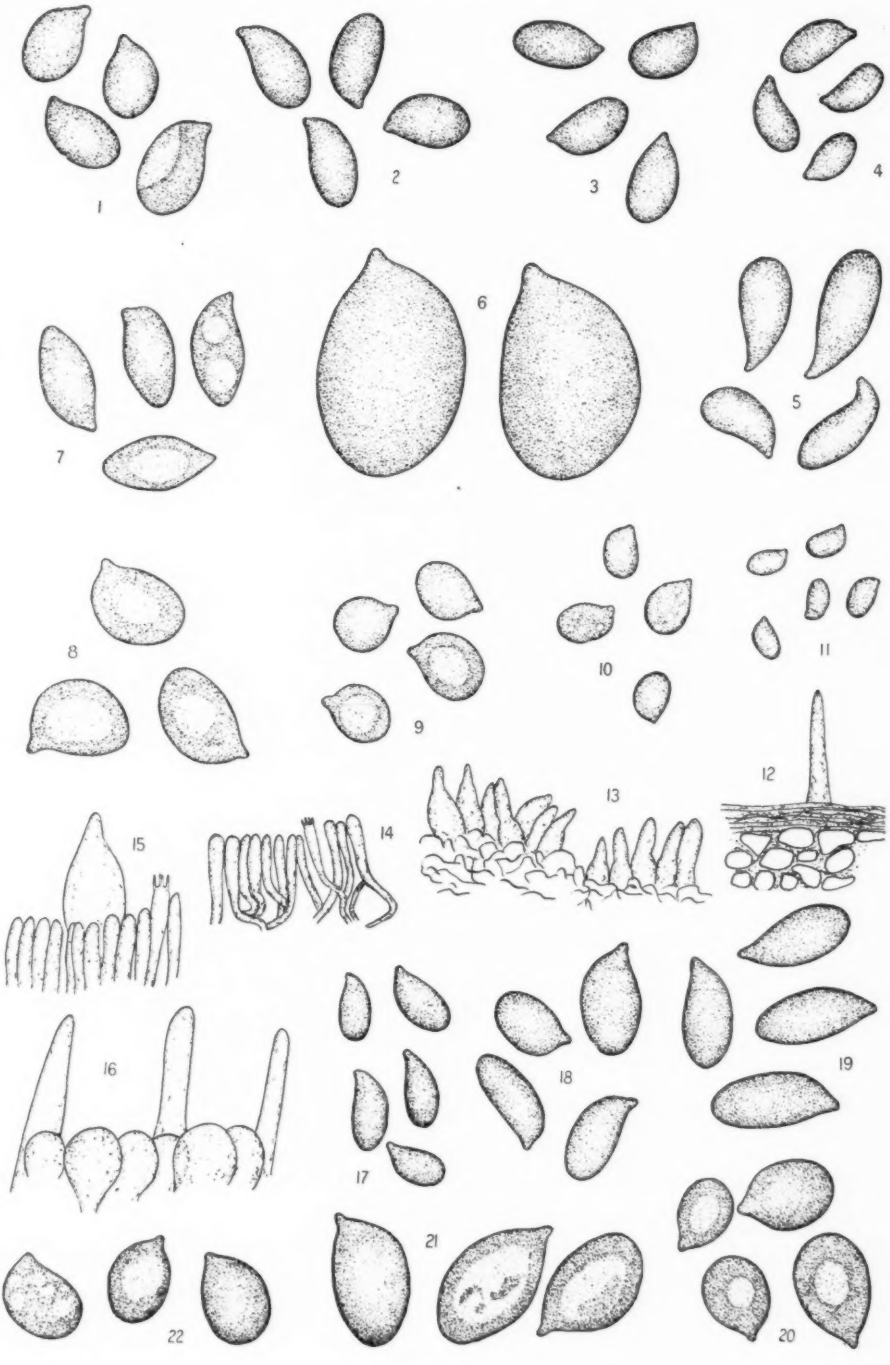
This interesting plant was found in abundance in Sweden in 1905. I have since seen it in similar places in Maine. When first found it could not be determined with certainty, though its abundance in one of Fries' collecting grounds indicated that it could not have escaped him, especially as it is more than usually striking. Lange's excellent notes on *Collybia* made it possible to identify it as above. Schroeter has an excellent description as Lange points out in Pilze Schlesiens, page 642, which exactly fits our plant. Fries' description does not fit as well. Cooke's figure is not a good representation of our plant. Ricken's description presents some difficulties. There seems little doubt that our plant is *C. clusilis* in the sense of Lange and Schroeter.

As it occurred in Sweden good opportunities for studying it were given. Successive crops of specimens appeared after rains in the same moss patches and its variations could be observed. The shape of the cap seemed to vary considerably. What seemed to be the typical form uniformly showed a slight umbo, or papilla. Other plants were rounded or even depressed at the center, though scarcely so as to be called umbilicate. The type material of *Mycena palustris* (Pk.) Sacc. has been carefully compared with our specimens and found to be identical, though the description seems to indicate a discrepancy in regard to the gills.

1532.* In a thick, dense bed of a large moss (*Dicranum scoparium*), woods south of cemetery, December 4, 1913. It has also appeared in a similar bed of the same moss near the sphagnum bed east of athletic field.

Chapel Hill, N. C.
Perry, Ohio.

PLATE 23



EXPLANATION OF PLATE 23.

Collybia maculata. No. 594. Fig. 1.
Collybia butyracea. No. 1902. Fig. 2.
Collybia dryophila. No. 3049. Fig. 3.
Collybia Earleae. No. 3052. Fig. 4.
Collybia nummularia. No. 584. Fig. 5.
Collybia radicata. No. 372. Fig. 6.
Collybia semitalis. No. 3869. Fig. 7.
Collybia platyphilla. No. 3276. Fig. 8.
Collybia exsculpta. No. 4543. Fig. 9.
Collybia cirrata. No. 3491. Fig. 10.
Collybia conigena No. 3503. Fig. 11, spores; fig. 12, hair on cap; fig. 13, cystidia on gill margin; fig. 14, basidium.
Collybia conigenoides. No. 3545. Fig. 15, basidium and cystidium; fig. 16, hairs and swollen cells on cap surface; fig. 17, spores.
Collybia velutipes. No. 2013. Fig. 18.
Collybia confluens. No. 3533. Fig. 19.
Collybia zonata. No. 1577. Fig. 20.
Collybia stipitaria. No. 3370. Fig. 21.
Collybia lilacina. No. 3290. Fig. 22.
Figs. 12–16 × 670; others × 2160.

Effect of the Relative Length of Day and Night and Other Factors of the Environment on Growth and Reproduction in Plants. By W. W. Garner and H. A. Allard.

(Note: The authors have furnished by request the following abstract of their work. Mr. Allard was assistant in Botany in the University of North Carolina in 1904–05. Both authors are now in the Department of Agriculture, Washington. Their paper under the above title was published in Journ. Agr. Research **18**, No. 11, 1920.)

Although the intensity of the light and the quality as regards wavelength of radiation are recognized as important factors in the development of plants, the present paper deals mainly with the behavior of the plant in response to the daily duration of the period of light. This phase of the subject of light effects upon plants appears to have received little attention in the past but in the present paper sufficient evidence has been accumulated to show that it has an extremely important bearing on the expression of plants as regards growth, stature, and specialization in the direction of sexual reproduction.

The main feature of the present paper is a demonstration of the fact that with many plants, sexual reproduction in some manner is a function of the relative length of the day and night. In other words, by artificially shortening the summer daily illumination period by keeping certain plants in a dark house for suitable periods of the day, sexual reproduction or flowering is initiated. Thus, the plants may be made to bloom at will, weeks or months in advance of controls responding to the normal seasonal length of day. Thus, certain late varieties of soy beans, namely Biloxi and Tokio, in particular, and the variety of tobacco known as Maryland Mammoth, have shown themselves very responsive to such conditions. The wild aster, *Aster linariifolius*, and other species also blossomed precociously, so to speak, when the length of day was reduced to 12 hours or 7 hours, respectively. Plants of this class may be considered short day plants, since sexual reproduction has been initiated by a length of day considerably shorter than the normal summer day which tends to promote vegetative growth, until the shorter days of late summer and autumn intervene to initiate flower and seed production.

On the other hand, certain plants have consistently shown a different behavior, and have failed to bloom in response to a day length of 7 hours, as obtained by the use of the dark house. Climbing Hemp

weed (*Mikania scandens*), wild Hibiscus (*Hibiscus Moscheutos*) and the common garden variety of radish (Scarlet Globe) are members of this class. For the sake of convenience these plants have been termed long day plants, indicating that they attain sexual reproduction successfully when the days are relatively long.

By the use of electric light of low intensity to increase the relatively short duration of illumination of the winter days, results in line with those obtained when the summer day has been shortened, were secured. Thus, soy beans and cosmos blossomed weeks and months after the controls enjoying the normal duration of illumination of the winter days.

It is evident that the duration of the daily illumination in itself is of primary significance in controlling the course of development toward or away from the flowering stage or sexual reproduction.

Experiments with several so-called late varieties of soy beans in the field, planted at intervals from April to August, have shown that the shortening of the period from planting till the first appearance of blossoms, is dependent upon the seasonal length of day to which the successive plantings have been subjected.

In the light of these results it is believed that the natural distribution of plants is governed more or less directly by the seasonal length of day which obtains for the different latitudes of the earth from the equator to the poles.

From the evidence at hand it will be seen that the stature and season of flowering of certain plants is dependent upon a favorable length of day, and this may actually be a most important limiting factor in determining crop yields in many instances. In other words, the time for propitious seeding to obtain maximum yields may be governed very largely by the length of day to which the crop will be exposed.

Since it has been shown that certain plants respond with a definite behavior to certain day lengths, the term "photoperiodism" is suggested to designate this response.

TEACHING OF GEOMETRY. By Archibald Henderson, Professor of Pure Mathematics, University of North Carolina.

If this paper (a pamphlet of 49 pages, Univ. N. C. Extension Series No. 33) simply followed the usual treatment of books on "The Teaching of Geometry," it would not call for special mention; but, as it strikes a distinct note, and gives many fresh discussions not found

in our geometries, it seems appropriate to call attention to it as an original work of high scientific value that should prove not only helpful, but stimulating to teachers and students in geometry.

In the Introduction, Dr. Henderson properly calls attention to the lessons of the world war as to the prime necessity of Mathematics relative to the scientific progress, welfare and preservation of a nation, which naturally recalls the saying of Napoleon that, "The advancement, the perfecting of mathematics, are bound up with the prosperity of the state."

In discussing "The Aims and Results of Geometrical Study," the author emphasizes the fact that the true purpose of instruction in geometry is to develop the faculty of independent thinking in geometry, to acquire facility in working problems—"originals," as they are happily called—in other words, to train the student as an investigator —a research worker. There can be no question as to the correctness of this point of view. Students so trained, take an increasing interest in the study—they "make good—" whereas, those neglecting this discipline, soon lose their mental self-reliance and intellectual courage to tackle new problems and difficulties, become discouraged, resort to mere memorizing, and thus, ultimately fail.

The author next takes up "The Problem of Instruction," and advocates the natural method of instruction, even when it is longer than the usual synthetic method. The usual text-books, following almost exclusively the synthetic method, are models of "Compression, elegance and rigor;" but they, too often, leave the student puzzled as to what the author is driving at, until the end is reached; when, presto, a conclusion is reached which comes as a distinct surprise to the reader, who has not been prepared for the denouement by being given the reasons for the successive steps of the demonstration.

By the synthetical method, whether for the demonstration of theorems or the solution of problems, we start from known theorems or problems and endeavor to effect a solution; but, as it is often difficult to know from what known theorems or problems to start, a series of fruitless essays may be made before hitting upon the proper solution.

On the contrary, by the natural method—that of the "old analysis" of Plato—we have the advantage of a starting point, the thing to be proved; and from that, an endeavor is made, by logical processes, to reach a known result. When this is attained, then if the successive

results are reciprocal, or each can be obtained from the one that follows, the theorems or problem posited in the beginning is true; since it can be proved by the synthetical method, by reversing the steps and working from the first conclusion or known results.*

The method of analysis is generally that of research and discovery; and because of its importance to the investigator and because of the slight attention accorded it in existing texts, Dr. Henderson has, purposely, given a number of illustrations of its working in solutions of theorems and problems. In fact, the treatment by the analytical method of problems and theorems is one distinctive feature of the paper, which should appeal particularly to the eager student who aims at any research in geometry.

"The Basic Problems of Construction" are treated by the author in an interesting manner. Most of the constructions are simple; some are complex, and are given as stimulating problems, since one object of the paper is to give new and instructive points of view.

This is especially noted in the section entitled "The Problem of Research," where the various modes of approach to the solution of geometrical problems are indicated, and numbers of illustrations are given with a completeness and elegance of demonstration that causes one to regard this section as the most interesting part of the essay.

The scope of this section can be judged from the following subheadings:

1. The Method of Analysis,
2. The Method of Successive Substitutions,
3. The Method of Reductis Ad Absurdum,
4. The Method of Intersection of Loci,
5. The Method of Construction of Loci by Points,
6. The Method of Transformation; Construction of Auxiliary Figures,
7. The Method of Parallel Translation,
8. The Method of Rotation Symmetry,
9. The Algebraic Method,
10. The Method of Similarity.

The final sections on "Procedure in Attacking Geometrical Problems" and a Biographical Note complete the subject.

The paper is illustrated with 26 figures, and is written in the attractive style one has come to associate with the author. It is plainly intended for teachers and research workers, for the author is a firm

* See Duhausel's "Des Méthodes dans les Science de Raisonnement," vols. 1 and 2; also, Cain's "Symbolic Algebra and Notes on Geometry" (D. Van Nostrand Co., New York) for a full discussion of the analytic method, including the cases of "lost" solutions and of those "strange" to the questions.

believer in that method of instruction which constantly calls for the working of "originals", and this brochure should prove especially helpful and inspiring to both teacher and student in pursuing this plan.

WM. CAIN

The following three abstracts were published in the University of North Carolina Record No. 179, Graduate School Series No. 2, August 1920.

IN REGARD TO SPECIES AND SPONGES. By H. V. Wilson. *The Scientific Monthly*, October, 1919.

A comparative study of sponge species indicates that hereditary characters are independently subject to variation such that in respect to any one of them individuals and races occur which form close series between far distant extremes. Such series are doubtless in many cases phylogenetic ones in which the terms bear to one another the relation of ancestral species and descendant. In other cases it would seem that the terms of the series represent only different degrees in the environmental stimuli which related protoplasms have made independently of one another.

It is recognized that the gene theory which assumes the existence in the germ cell of minute units, representative of the hereditary characters, is applicable to the facts stated above, as well as to the facts of Mendelian inheritance in particular, if only we assume enough units in the germ cell. In thus extending the theory to cover all forms of heritable differences between organisms, it may be questioned whether it retains any practical (pragmatic) value. Nevertheless it would seem that symbolism of this sort does contribute to precision of thinking, if it be recognized for what it is, viz., conceptual symbolism.

It is called to mind that many today would remove the gene from the conceptual world and give it a perceptible body, that is, they would identify it with a chromatin granule. The known facts however do not necessitate, according to some even contradict, this view as to the nature of chromatin and chromosomes.

SPONGES OF BEAUFORT (N. C.) HARBOR AND VICINITY. By W. C. George and H. V. Wilson. *Bulletin U. S. Bureau of Fisheries*, XXXVI, Document 876. 1919. (Body of the paper accepted as a thesis for the Ph. D. degree awarded to W. C. George, 1918).

The paper includes a description of sponges present and in any de-

gree conspicuous in the Beaufort area. Seventeen species are described, most of them new. Of these the "Fishing Bank," a bank of coralline nature with a West Indian fauna, to seaward of Beaufort Inlet, has yielded four. Collecting on the sea-beaches was incidental, most material so collected being unfit for precise study. The bulk of the sponges are harbor forms, at least eight sufficiently abundant to be available for investigations of an experimental nature. The occurrence of a minute horny sponge of very simple character, designated *Pleraplysilla latens*, is noteworthy, both because horny sponges as a group inhabit more southern waters and because of the morphological simplicity of the form.

The families, subfamilies, and genera represented are defined, and the paper may thus be used for purposes of identification. A considerable amount of comparative data falling under the general head of variation is recorded, and in the case of a number of the genera there is discussion of the facts on which they rest. The illustrations, of entire sponges and microscopic preparations, are for the most part photographic.

ASYMMETRICAL REGULATION IN ANURAN EMBRYOS WITH *Spina bifida* DEFECT. By H. V. Wilson and Blackwell Markham. *Journal Experimental Zoology*, XXX. 1920. (Body of the paper accepted as a thesis for the M. A. degree awarded to Blackwell Markham, 1918.)

Abnormal embryos and larvae of the frog and toad are described, the developmental processes in which add to our knowledge of what is called the regulatory power of organisms. This is the power which enables an organism, lower adult or embryo of higher form, to restore or develop the typical form of body, after the destruction or amputation of a part of the whole, or after some interference in development which blocks the normal course of differentiation. In the particular cases described the normal backward growth of the axial structures of the embryonic body, such as notochord and spinal cord, is prevented. In a well-known type of embryo of this sort the tissue of the blastopore lips, two stripes which diverge from the posterior end of the embryonic body, becomes organized, each stripe forming a half spinal cord, half notochord, etc., the half structures gradually coming together (process of 'concrescence') in the median line to form a complete spinal cord, complete notochord, etc. But in the embryos here described a different and asymmetrical kind of regulation is employed. Instead of both streaks (blastopore lips) organizing and fusing, only one streak

organizes. It organizes however in such a way as to produce not a half but the whole, that is, both right and left halves of the trunk of the body. Thus the end result, the production of a typical form, may be reached by very different paths. This variety in the fundamental formative processes of which an embryo is capable makes it impossible to think of development as at bottom a deterministic process, viz., as one in which the embryo is a machine composed of (self-propagative) parts each the material cause and origin of a particular portion of the body.

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